Influence of thermophoresis and thermal radiation on mass transfer and heat of Three Dimensional maxwell fluid in presence of Magnetic field

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ABSTRACT

The study is about Maxwell , three dimensions of non – Newtonian fluid. Method of th Homotopy applied to analysis mass transfer and heat with thermophoresis effects. Impact of therrmophoretic (τ), magnetic (M), Biot (γ), radiation (Rd), Schmidt (Sc), Prandtle (Pr) parameters and ratio parameter(β) on concentration, temperature are offered in the paper

Keywords: Maxwell fluid, magnetic field, mass transfer , three dimensions fluid

1. Introduction

Mass transfer, heat are processes submitted by mathematical equations in diffusion and convection ,This subject in the boundary flow is significant, for example, growing of crystal, , extrusion of polymer, glass-fiber, and many others .

The phenomenon of movmoment of fluid particles from warm region in the direction the cold region is known a thermophoresis, this motion occurs because molecules with higher energy from the kinetic warmer region , hit with molecules in cooler area with low energy.

A thermophoretic velocity mean the velocity gained the particles , while the force to which the particles are exposed are denominated the thermophoretic force .

[1] . lately, researchers has been concentering on model of Maxwell fluid. Ganeshkumar.k,Rudraswamy.N.G,Gireesha.B.Jand Krishnamurth.M [2], made an impact for viscous dissipation and thermal radiation of nano fluid with joule heating , method of Runge - kutta and shooting used to find the solution. Koneril and others [3], discussed in the attendance of dust, particles the impact of radiation , use Maxwell fluid with magnetic field in this paper used a numerical method to obtain the solution and it show that the effect of the parameters which appear on the flow . Must and others [4] submitted Maxwell fluid for sakiads flow with magnetic field . Vijayaa. N ,Krishna Jyothb. P , Anupamac. A , Leelavathid. R , Ambicae. K[6] presented model of Cattaneo- christov heat flux to show influence thermophorsis and buoyancy on chemical reaction of Maxwell fluid.

This article discusses the impact of thermophoresis ,thermal radiation of Maxwell fluid with magnetic field in three dimensions space. The technique that was used to solve the problem is homotopy [5,8].

2. Formulation

Assume that the coordinates are Cartesian, , three dimensional maxwell fluid , the field is magnetic, the surface is inclined stretching , T_∞ is temperature interface and T_f is surface temperature .

The equations for present flow are

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0 \qquad (1)$$

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}=\upsilon\frac{\partial^2 u}{\partial y^2}-\lambda\left(u^2\frac{\partial^2 u}{\partial x^2}+v^2\frac{\partial^2 u}{\partial y^2}+w^2\frac{\partial^2 u}{\partial z^2}+2\left(u\,v\frac{\partial^2 u}{\partial x\,\partial y}+v\,w\frac{\partial^2 u}{\partial y\,\partial z}+u\,w\frac{\partial^2 u}{\partial x\,\partial z}\right)\right)-\frac{\sigma\beta_0^2 u}{\rho} \qquad (2)$$

$$u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}=\upsilon\frac{\partial^2 v}{\partial y^2}-\lambda\left(\frac{u^2\,\partial^2 v}{\partial x^2}+\frac{v^2\,\partial^2 v}{\partial y^2}+\frac{w^2\,\partial^2 v}{\partial z^2}+2\left(u\,v\frac{\partial^2 v}{\partial x\,\partial y}+w\,v\frac{\partial^2 v}{\partial y\partial z}+w\,u\frac{\partial^2 v}{\partial x\partial z}\right)\right) \qquad (3)$$

$$\rho\ c_\rho\left(u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}+w\frac{\partial T}{\partial z}\right)=\frac{\partial}{\partial z}\left(\left(\frac{16\sigma^*}{3k^*}T_\infty^3+k\right)\frac{\partial T}{\partial z}\right) \qquad (4)$$

$$u\frac{\partial c}{\partial x}+v\frac{\partial c}{\partial y}+w\frac{\partial c}{\partial z}=D_e\frac{\partial^2 c}{\partial z^2}-\frac{\partial}{\partial z}\left(V_T(c-c_\infty)\right) \qquad (5)$$

Considering that

v,u with w represent the velocities

λ relaxation time

σ^* electrical conductivity

g the gravitational acceleration

T mean the temperature

β_T thermal coefficient

β_c concentration expansion coefficient

$\upsilon = \left(\frac{\mu}{\rho}\right)$ kinematic viscosity , μ , ρ are represent the dynamic viscosity and density of fluid respectively

σ thermal diffusivity

C concentration

K_T ratio of thermal diffusion

$V_T = -k_2\frac{\nu}{T_r}\frac{\partial T}{\partial z}$ thermophoretic velocity ,

k_2 thermophoretic coefficient

T_r reference temperature

D_e mass diffusivity

$\tau = -k_2\ \frac{T_f - T_\infty}{T_r}$ Thermophoretic parameter

β_0 Strength of Magnetic field

k thermal conductivity

T_f ambient temperature

C_∞ ambient concentration

Put the boundary conditions

$u = u_e = a\,x$

$v = Ъ_y$, w =0,-k*/(T$_f$ -T)$\frac{\partial T}{\partial z}$ = h , c = c$_w$ at z = 0

u converge to zero , v converge to zero , T converge to T_∞ ,C converge to C_∞ at z $\to \infty$

Note that ɑ and Ъ owns dimension reverse time.

Let

$$\left.\begin{aligned} u &= ɑ_x\, f'(\eta) \\ v &= ɑ_y\, g'(\eta) \\ w &= -\sqrt{ɑv}\,(f(\eta) + g(\eta)) \end{aligned}\right\} \qquad (6)$$

$\theta(\eta) = (T - T_\infty) / (T_f - T_\infty)$

$\eta = z\,\sqrt{ɑ}/v$

$\Phi(\eta) = (c - c_\infty)/(c_w - c_\infty)$

Substitute (6) in equations(2- 5)

$$f''' + (f+g)\, f'' - M f' - \beta_1[(f+g)^2 f''' - 2f'(f+g)\, f''] - (f')^2 = 0 \qquad (7)$$

$$g''' + (f+g)\, g'' + \beta_1[2(f+g)\, g' g'' - (f+g)^2 g'''] - (g')^2 = 0, \qquad (8)$$

$$(1 + 4R/3)\, \theta'' + pr\, \theta'(f+g) = 0 \qquad (9)$$

$$\Phi'' + Sc\, \Phi'(f+g) - Sc\tau(\Phi'\theta' - \Phi\theta'') = 0 \qquad (10)$$

and

at $\eta = 0$

$f = 0$

$f' = 1$

$g = 0$

$g' = \beta$

$\theta' = -\gamma(1 - \theta(o))$, Φ=1

at η converge to ∞

f' converge to 0

g' converge to 0

θ converge to 0

ϕ converge to 0

Note $\beta_1 = \lambda_1 a$, β = b/a , $v\sigma$ = pr , $\gamma = h/k*\sqrt{v/a},$ (biot number) , σ^* represent Stefan –Boltzmann constant , β_T is the coefficients of thermal expansion) , c_p mean specific heat) , k^* the coefficient of absor ption , k=k_1a , sc = ν/D , λ =GrxRe2x (local buoyancy) , Grx=g β_T ($T_f - T_\infty$) $\frac{x^3}{v^2}$ (local grashof number) , $\frac{\beta C}{\beta T}\,\frac{(Cw - C\infty)}{(Tf - T\infty)}$ = N (constant dimensionless concentration buoyancy parameter) , M=$\frac{\sigma\beta_0^2}{a\rho}$ (parameter of magnetic field) .

3. Solution method

To resolve the issue ,we'll use homotopy method , which demands the approximations

$f_0(\eta) = 1 - \exp(-\eta)$

$g_0(\eta) = -(\exp(-\eta) - 1)\beta$

$\theta_0(\eta) = (\exp(-\eta) + 1)\gamma$

$\phi_0(\eta) = \exp(-\eta)$

and the linear transformations

$L_1 = f'''(\eta) - f'(\eta)$, $L_2 = g'''(\eta) - g'(\eta)$

$L_3 = \theta''(\eta) - \theta(\eta)$, $L_4 = \Phi''(\eta) - \Phi(\eta)$,

$$L_1(A_1 + A_2 e^{\eta} + A_3 e^{-\eta}) = 0,$$

$$L_2(A_4 + A_5 e^{\eta} + A_6 e^{-\eta}) = 0$$

$$L_3(A_7 e^{\eta} + A_8 e^{-\eta}) = 0, \qquad (11)$$

$$L_4(A_9 e^{\eta} + A_{10} e^{-\eta}) = 0,$$

$A_1, A_2, A_3, \ldots, A_{10}$ are constants.

The issue is from order zero :

$$(1-\Im)L_1[\tilde{f}(\eta;\Im) - f_0(\eta)] = \Im\hbar_1 N_1[\tilde{f}(\eta;\Im), \tilde{g}(\eta;\Im)],$$

$$(1-\Im)L_2[\tilde{g}(\eta;\Im) - g_0(\eta)] = \Im\hbar_2 N_2[\tilde{f}(\eta;\Im), \tilde{g}(\eta;\Im)],$$

$$(1-\Im)L_3[\tilde{\theta}(\eta;\Im) - \theta_0(\eta)] = \Im\hbar_1 N_1[\tilde{f}(\eta;\Im), \tilde{g}(\eta;\Im), \tilde{\theta}(\eta,\Im), \tilde{\Phi}(\eta,\Im)],$$

$$(1-\Im)L_4[\tilde{\phi}(\eta;\Im) - \Phi_0(\eta)] = \text{Ƥ}\hbar_2 N_2[\tilde{f}(\eta;\Im), \tilde{g}(\eta;\Im), \tilde{\theta}(\eta,\Im), \tilde{\Phi}(\eta,\Im)],$$

$$\tilde{f}(0,\Im) = 0, \tilde{f}'(\infty,\Im) = 0, \tilde{f}'(0,\Im) = 1,$$

$$\tilde{g}(0,\Im) = 0, \tilde{g}'(\infty,\Im) = 0, \tilde{g}'(0,\Im) = \beta, \tilde{g}(\infty,\Im) = 0$$

$$\tilde{\theta}'(0,\Im) = -\gamma[1-\theta(0,\Im)], \tilde{\theta}(\infty,\Im) = 0, , \tilde{\Phi}(0,\Im) = 1, \tilde{\Phi}(\infty,\Im) = 0$$

$$N_1[\tilde{f}(\eta;\Im), \tilde{g}(\eta;\Im)] = \frac{\partial^3\tilde{f}(\eta;\Im)}{\partial\eta^3} + (\tilde{f}(\eta;\Im) + \tilde{g}(\eta;\Im))\frac{\partial^2\tilde{f}(\eta;\Im)}{\partial\eta^2} - M\frac{\partial\tilde{f}(\eta;\Im)}{\partial\eta} + \beta^*[\frac{2\,\partial\tilde{f}(\eta;\Im)}{\partial\eta}(\tilde{f}(\eta;\Im) + \tilde{g}(\eta;\Im))\frac{\partial^2\tilde{f}(\eta;\Im)}{\partial\eta^2} - (\tilde{f}(\eta;\Im) + \tilde{g}(\eta;\Im))^2\frac{\partial^3\tilde{f}(\eta;\Im)}{\partial\eta^3}] - (\frac{\partial\tilde{f}(\eta;\Im)}{\partial\eta})^2 \quad (12)$$

$$N_2[\tilde{f}(\eta;\Im), \tilde{g}(\eta;\Im)] = \frac{\partial^3\tilde{g}(\eta;\Im)}{\partial\eta^3})^2 + (\tilde{f}(\eta;\Im) + \tilde{g}(\eta;\Im))\frac{\partial^2\tilde{g}(\eta;\Im)}{\partial\eta^2} + \beta^*[2(\tilde{f}(\eta;\Im) + \tilde{g}(\eta;\Im))\frac{\partial\tilde{g}(\eta;\Im)}{\partial\eta}\frac{\partial^2\tilde{g}(\eta;\Im)}{\partial\eta^2} - (\tilde{f}(\eta;\Im) + \tilde{g}(\eta;\Im))^2\frac{\partial^3\tilde{g}(\eta;\Im)}{\partial\eta^3}] - (\frac{\partial\tilde{g}(\eta;\Im)}{\partial\eta})^2 \quad (13)$$

$N_3[\tilde{\theta}(\eta,ʅ), \tilde{\Phi}(\eta,ʅ), [\tilde{f}(\eta,ʅ), \tilde{g}(\eta,ʅ)] = (1+4/3\ R)\frac{\partial^2\tilde{\theta}(\eta,ʅ)}{\partial\eta^2} + pr(\tilde{f}(\eta,ʅ)+\tilde{g}(\eta,ʅ))\frac{\partial\tilde{\theta}(\eta,ʅ)}{\partial\eta}$ (14)

$N_4[\tilde{\Phi}(\eta,ʅ), \tilde{\theta}(\eta,ʅ), \tilde{f}(\eta,ʅ), \tilde{g}(\eta,ʅ)] = \frac{\partial^2\tilde{\Phi}}{\partial\eta^2} + sc\,(\tilde{f}(\eta,ʅ)+\tilde{g}(\eta,ʅ))\frac{\partial\tilde{\Phi}}{\partial\eta} - sc\,\tau\,(\frac{\partial\tilde{\Phi}}{\partial\eta}\frac{\partial\tilde{\theta}(\eta,ʅ)}{\partial\eta} - \tilde{\phi}(\eta,ʅ)\frac{\partial^2\tilde{\theta}(\eta,ʅ)}{\partial\eta^2})$, (15)

ʅ and $\hbar_1, \ldots, \hbar_n$ (n=1,2,3,4) mean embedding, auxiliary parameters respectively

N_1, N_2, N_3, N_4 nonlinear transformations.

at ʅ = 0 , ʅ = 1
$\tilde{f}(\eta,0) = f_0(\eta)$, $\tilde{f}(\eta,1) = f(\eta)$, $\tilde{g}(\eta,0) = g_0(\eta)$, $\tilde{g}(\eta,1) = g(\eta)$,
$\tilde{\theta}(\eta,0) = \theta_0(\eta)$, $\tilde{\phi}(\eta,0) = \phi_0(\eta)$, $\tilde{\theta}(\eta,1) = \theta(\eta)$, $\tilde{\phi}(\eta,1) = \phi_0(\eta)$. (16)

By Taylor's expansion

$f(\eta,ʅ) = f_0(\eta) + \sum_{m=1}^{\infty} f_m(\eta)\,ʅ^m$, $f_m(\eta) = 1/(m!)\frac{\partial^m f(\eta;ʅ)}{\partial\eta^m}]_{ʅ=0}$
$g(\eta,ʅ) = g_0(\eta) + \sum_{m=1}^{\infty} g_m(\eta)\,ʅ^m$, $g_m(\eta) = 1/(m!)\frac{\partial^m g(\eta;ʅ)}{\partial\eta^m}]_{ʅ=0}$
(17)

$\theta(\eta,ʅ) = \theta_0(\eta) + \sum_{m=1}^{\infty} \theta_m(\eta)\,ʅ^m$, $\theta_m(\eta) = 1/(m!)\frac{\partial^m \theta(\eta;ʅ)}{\partial\eta^m}]_{ʅ=0}$

$\phi(\eta,ʅ) = \phi_0(\eta) + \sum_{m=1}^{\infty} \phi_m(\eta)\,ʅ^m$, $\phi_m(\eta) = 1/(m!)\frac{\partial^m \phi(\eta;ʅ)}{\partial\eta^m}]_{ʅ=0}$

by choosing the series (17) convergent when ʅ =1 so

$f(\eta) = f_0(\eta) + \sum_{m=1}^{\infty} f_m(\eta)$,

$g(\eta) = g_0(\eta) + \sum_{m=1}^{\infty} g_m(\eta)$,

$\theta(\eta) = \theta_0(\eta) + \sum_{m=1}^{\infty} \theta_m(\eta)$,

$\phi(\eta) = \Phi_0(\eta) + \sum_{m=1}^{\infty} \Phi_m(\eta)$.

The issue that's generated from deformation of order m :
$L_1[f_m(\eta) - x_m f_{m-1}(\eta)] = \hbar_1 R_{1m}(\eta)$,

$L_2[g_m(\eta) - x_m g_{m-1}(\eta)] = \hbar_2 R_{2m}(\eta)$,

$L_3[\theta_m(\eta) - x_m \theta_{m-1}(\eta)] = \hbar_3 R_{3m}(\eta)$,

$L_4\,[\Phi_m(\eta) - x_m\,\Phi_{m-1}(\eta)] = \hbar_4 R_4 m(\eta)$,

$f_m(0) = 0 = g_m(0)$, $f'_m(0) = g'_m(0) = 0 = f'_m(\infty) = g'_m(\infty)$

$\theta'_m(0) - \gamma\,\theta_m(0) = 0$

$\theta_m(\infty) = 0 = \Phi_m(\infty) = \Phi_m(0)$

R_1^m=D[f $_{-1+m}$, η , η , η] – (M*D[f$_{-1+m}$, η])- $\sum_{k=0}^{m-1}$ ([f$_{m-1-k}$, η]*D[f$_k$, η])+ $\sum_{k=0}^{m-1}$ ((f$_{m-1-k}$D[f$_k$, η,η]))+ β$\sum_{k=0}^{m-1}$ $\sum_{i=0}^{k}$ ((f$_{m-1-k}$+ g$_{m-1-}$

$_k$)*2D[fk-i, η] *D[fi, η,η])- ((((f$_{m-1-k}$) (f$_{k-i}$)) +((g$_{m-k-1}$) (g$_{k-i}$))) + (((f$_{m-1-k}$) (g$_k$-i))))*2D[f$_i$, η,η]. (18)

R_2^m = D[g$_{m-1}$, η, η , η] $-$ $\sum_{k=0}^{m-1}$ (D[g$_{m-k-1}$, η] D[g$_k$, η]) + $\sum_{k=0}^{m-1}$ ((f$_{m-k-1}$ D[g$_k$, η , η]) + ((g$_{m-1-k}$ D[g$_k$, η , η])) + β

$\sum_{k=0}^{m-1}$ $\sum_{i=0}^{k}$ (2 D[g$_{k-i}$, η](f_{m-1-k} + g$_{m-k-1}$) D[g$_i$, η , η]$-$(((f$_{m-k-1}$ f$_{k-i}$)+ (g$_{m-k-1}$ g$_{k-i}$) + (2* (f$_{m-k-1}$ g$_{k-i}$))) D[g$_i$, η , η , η]. (19)

$R_3^m = (1 + (4/3)\mathrm{Rd}) * D[\theta_{m-1},\eta,\eta] + (\Pr * \sum_{k=0}^{m-1} \quad ((D[\theta_{m-1-k},\eta] * f_k) + (D[\theta_{m-1-k},\eta] * g_k)))$ (20)

$R_4^m = D[\phi_{m-1},\eta,\eta] + (\mathrm{Sc} * \sum_{k=0}^{m-1} \quad ((D[\phi_{m-1-k},\eta]) * f_k + (D[\phi_{m-1-k},\eta] * g_k))) - (\mathrm{Sc} * \tau * \sum_{k=0}^{m-1} \quad ((D[\phi_{m-1-k},\eta]) *$

$D[\theta_k,\eta] - (\phi_{\,m-1-k} * D[\theta_k,\eta,\eta])))$ ..(21)

It easy to solve the equations(16-19) using mathematic software ,so we get

$$f_1 = \frac{1}{24}e^{-3\eta}(h1\beta(-1+\beta^2) - 4e^{\eta}h1\beta(1+2\beta+2\beta^2) - 6e^{2\eta}(h1(M+\beta(2+2$$
$$+\beta^2))(3+2\eta) + 4(\tfrac{1}{24}(24 - 6h1M - 23h1\beta - 28h1\beta^2 - 19h1\beta^3))))..(22)$$

$$f_2 = \frac{1}{2880}e^{-5\eta}(h1^2\beta^2(3+32\beta+22\beta^2-32\beta^3-25\beta^4) + 8e^{\eta}h1^2\beta(-1-14\beta-20\beta^2+13\beta^3+53\beta^4+$$
$$29\beta^5) + 5e^{2\eta}h1\beta\Big(96(-1+\beta^2) + h1\Big(-26 + 9\beta^5(-15+4\eta) + 4\beta^3(-80+9\eta) + 8\beta^4(-43+9\eta) -$$
$$2\beta^2(91+36\eta) - \beta(73+72\eta) + 2M\big(-18(1+\eta) + \beta^2(-7+6\eta)\big)\Big)\Big) \quad ..(23)$$

$$f_3 = \frac{1}{2419200}e^{-7\eta}(5h^3\beta^3(-155-1408\beta-3967\beta^2-2880\beta^3+2695\beta^4+4288\beta^5+1427\beta^6) -$$
$$4e^{\eta}h1^3\beta^2(-240-4751\beta-24522\beta^2-39788\beta^3+36\beta^4+67749\beta^5+67862\beta^6+20054\beta^7) -$$
$$7e^{2\eta}h1^2\beta(840\beta(-3-32\beta-22\beta^2+32\beta^3+25\beta^4) \quad ..(24)$$

$$f_4 = -\frac{1}{174182400}e^{-9\eta}h1^4\beta^4(-17619-213424\beta-917030\beta^2-1745360\beta^3-1162248\beta^4+$$
$$859184\beta^5+1874270\beta^6+1099600\beta^7+222627\beta^8) + \frac{1}{304819200}e^{-8\eta}h1^4\beta^3(-41910-1003527\beta-$$

$7123122\beta^2 - 22075329\beta^3 - 30357442\beta^4 - 4581577\beta^5 + 40482514\beta^6 + 52695097\beta^7 + 27280216\beta^8 + 5205080\beta^9))$ ..(25)

$g_1 = \frac{1}{24}e^{-3\eta}(-h2\beta^2(-1+\beta^2) - 4e^{\eta}h2\beta(1+2\beta+2\beta^2) - 6e^{2\eta}(h2\beta^2(2+2\beta+\beta^2)(3+2\eta) + 4(\frac{1}{24}(24\beta - 8h2\beta - 25h2\beta^2 - 28h\beta^3 - 9h2\beta^4)))) + \frac{1}{12}(12\beta - 2h2\beta + 9h2\beta^2 + 8h2\beta^3 + 5h2\beta^4)$ ..(26)

$g_2 = \frac{1}{2880}e^{-5\eta}(h2^2\beta^3(-25 - 32\beta + 22\beta^2 + 32\beta^3 + 3\beta^4) - 8e^{\eta}h2^2\beta^2(-10 - 38\beta - 47\beta^2 - 2\beta^3 + 29\beta^4 + 8\beta^5) - 5e^{2\eta}h2\beta(96\beta(-1+\beta^2) + h2(16 + \beta^2(265 - 72\eta) + \beta^3(386 - 72\eta) + 12\beta^4(23 + 3\eta) + 8\beta^5(5+9\eta) + \beta^6(3+36\eta) + \beta(94 - 50M - 24M\eta)))$ ..(27)

$g_3 = \frac{1}{2419200}e^{-7\eta}\ (-5h2^3(-1427\beta^4 - 4288\beta^5 - 2695\beta^6 + 2880\beta^7 + 3967\beta^8 + 1408\beta^9 + 155\beta^6) + 4e^{\eta}h2^3(-5361\beta^3 - 34054\beta^4 - 73844\beta^5 - 57204\beta^6 + 16603\beta^7 + 46010\beta^8 + 19338\beta^9 + 2112\beta^{10})$ ..(28)

$\theta_1 = \frac{1}{12(1+\gamma)}e^{-2\eta}h\gamma(-3e^{\eta} + 4\mathrm{Pr} + 3e^{\eta}\mathrm{Pr} - 4e^{\eta}\mathrm{Rd} + 4\mathrm{Pr}\beta + 3e^{\eta}\mathrm{Pr}\beta - 6e^{\eta}\eta + 6e^{\eta}\mathrm{Pr}\eta - 8e^{\eta}\mathrm{Rd}\eta + 6e^{\eta}\mathrm{Pr}\beta\eta) + e^{-\eta}((12\gamma - 3h\gamma - 5h\mathrm{Pr}\gamma - 4h\mathrm{Rd}\gamma - 5h\mathrm{Pr}\beta\gamma + 12\gamma^2)/(12(1+\gamma)))$ . ..(29)

$\theta_2 = \frac{1}{2160(1+\gamma)}e^{-4\eta}(-1080e^{3\eta}h\gamma - 135e^{3\eta}h^2\gamma + 2160e^{2\eta}h\mathrm{Pr}\gamma + 1620e^{3\eta}h\mathrm{Pr}\gamma + 480e^{2\eta}h^2\mathrm{Pr}\gamma + 360e^{3\eta}h^2\mathrm{Pr}\gamma + 840e^{2\eta}h^2M\mathrm{Pr}\gamma + 270e^{3\eta}h^2M\mathrm{Pr}\gamma + 180e^{\eta}h^2\mathrm{Pr}^2\gamma - 480e^{2\eta}h^2\mathrm{Pr}^2\gamma - 225e^{3\eta}h^2\mathrm{Pr}^2\gamma - 1440e^{3\eta}h\mathrm{Rd}\gamma - 360e^{3\eta}h^2\mathrm{Rd}\gamma + 640e^{2\eta}h^2\mathrm{Pr}\mathrm{Rd}\gamma + 480e^{3\eta}h^2\mathrm{Pr}\mathrm{Rd}\gamma - 240e^{3\eta}h^2\mathrm{Rd}^2\gamma + 2160e^{2\eta}h\mathrm{Pr}\beta\gamma + 1620e^{3\eta}h\mathrm{Pr}\beta\gamma + 6h^2\mathrm{Pr}\beta\gamma + 90e^{\eta}h^2\mathrm{Pr}\beta\gamma + 1590e^{2\eta}h^2\mathrm{Pr}\beta\gamma + 675e^{3\eta}h^2\mathrm{Pr}\beta\gamma + 360e^{\eta}h^2\mathrm{Pr}^2\beta\gamma - 960e^{2\eta}h^2\mathrm{Pr}^2\beta\gamma - 450e^{3\eta}h^2\mathrm{Pr}^2\beta\gamma + 640e^{2\eta}h^2\mathrm{Pr}\mathrm{Rd}\beta\gamma + 480e^{3\eta}h^2\mathrm{Pr}\mathrm{Rd}\beta\gamma$ ..(30)

$\theta_3 = \frac{1}{5443200(1+\gamma)}e^{-6\eta}(-4082400e^{5\eta}h\gamma - 1020600e^{5\eta}h^2\gamma - 170100e^{5\eta}h^3\gamma + 10886400e^{4\eta}h\mathrm{Pr}\gamma + 8164800e^{5\eta}h\mathrm{Pr}\gamma + 6955200e^{4\eta}h^2\mathrm{Pr}\gamma + 4309200e^{5\eta}h^2\mathrm{Pr}\gamma + 957600e^{4\eta}h^3\mathrm{Pr}\gamma + 1058400e^{5\eta}h^3\mathrm{Pr}\gamma + 8467200e^{4\eta}h^2M\mathrm{Pr}\gamma + 2721600e^{5\eta}h^2M\mathrm{Pr}\gamma + 3427200e^{4\eta}h^3M\mathrm{Pr}\gamma + 1512000e^{5\eta}h^3M\mathrm{Pr}\gamma + 2242800e^{4\eta}h^3M^2\mathrm{Pr}\gamma + 510300e^{5\eta}h^3M^2\mathrm{Pr}\gamma + 2268000e^{3\eta}h^2\mathrm{Pr}^2\gamma - 6048000e^{4\eta}h^2\mathrm{Pr}^2\gamma - 2835000e^{5\eta}h^2\mathrm{Pr}^2\gamma + 756000e^{3\eta}h^3\mathrm{Pr}^2\gamma - 1915200e^{4\eta}h^3\mathrm{Pr}^2\gamma - 1152900e^{5\eta}h^3\mathrm{Pr}^2\gamma + 982800e^{3\eta}h^3M\mathrm{Pr}^2\gamma - 2520000e^{4\eta}h^3M\mathrm{Pr}^2\gamma - 945000e^{5\eta}h^3M\mathrm{Pr}^2\gamma + 90720e^{2\eta}h^3\mathrm{Pr}^3\gamma - 415800e^{3\eta}h^3\mathrm{Pr}^3\gamma + 504000e^{4\eta}h^3\mathrm{Pr}^3\gamma + 264600e^{5\eta}h^3\mathrm{Pr}^3\gamma - 5443200e^{5\eta}h\mathrm{Rd}\gamma$ . ..(31)

$\phi_1 = \frac{1}{12}e^{-2\eta}h(-3e^{\eta} + 4\mathrm{Sc} + 3e^{\eta}\mathrm{Sc} + 4\mathrm{Sc}\beta + 3e^{\eta}\mathrm{Sc}\beta - 6e^{\eta}\eta + 6e^{\eta}\mathrm{Sc}\eta + 6e^{\eta}\mathrm{Sc}\beta\eta) + e^{-\eta}(\frac{1}{12}(12 + 3h - 7h\mathrm{Sc} - 7h\mathrm{Sc}\beta))$. ..(32)

$\phi_2 = \frac{1}{720(1+\gamma)}e^{-4\eta}(-360e^{3\eta}h - 135e^{3\eta}h^2 + 720e^{2\eta}h\mathrm{Sc} + 540e^{3\eta}h\mathrm{Sc} + 280e^{2\eta}h^2\mathrm{Sc} + 240e^{3\eta}h^2\mathrm{Sc} + 280e^{2\eta}h^2M\mathrm{Sc} + 90e^{3\eta}h^2M\mathrm{Sc} + 60e^{\eta}h^2\mathrm{Sc}^2 - 200e^{2\eta}h^2\mathrm{Sc}^2 - 105e^{3\eta}h^2\mathrm{Sc}^2 + 720e^{2\eta}h\mathrm{Sc}\beta + 540e^{3\eta}h\mathrm{Sc}\beta + 2h^2\mathrm{Sc}\beta + 30e^{\eta}h^2\mathrm{Sc}\beta + 650e^{2\eta}h^2\mathrm{Sc}\beta + 345e^{3\eta}h^2\mathrm{Sc}\beta + 120e^{\eta}h^2\mathrm{Sc}^2\beta - 400e^{2\eta}h^2\mathrm{Sc}^2\beta - 210e^{3\eta}h^2\mathrm{Sc}^2\beta - 2h^2\mathrm{Sc}\beta^2 + 60e^{\eta}h^2\mathrm{Sc}\beta^2$ . ..(33)

$\phi_3 = \frac{1}{1814400(1+\gamma)^2}e^{-6\eta}(-1360800e^{5\eta}h - 1020600e^{5\eta}h^2 - 283500e^{5\eta}h^3 + 3628800e^{4\eta}h\mathrm{Sc} + 2721600e^{5\eta}h\mathrm{Sc} + 3528000e^{4\eta}h^2\mathrm{Sc} + 2646000e^{5\eta}h^2\mathrm{Sc} + 747600e^{4\eta}h^3\mathrm{Sc} + 743400e^{5\eta}h^3\mathrm{Sc} +$

$$2822400e^{4\eta}h^2M\mathrm{Sc} + 907200e^{5\eta}h^2M\mathrm{Sc} + 1495200e^{4\eta}h^3M\mathrm{Sc} + 630000e^{5\eta}h^3M\mathrm{Sc} + 747600e^{4\eta}h^3M^2\mathrm{Sc} + 170100e^{5\eta}h^3M^2\mathrm{Sc} + 756000e^{3\eta}h^2\mathrm{Sc}^2 - 2520000e^{4\eta}h^2\mathrm{Sc}^2 - 1323000e^{5\eta}h^2\mathrm{Sc}^2 + 327600e^{3\eta}h^3\mathrm{Sc}^2 - 974400e^{4\eta}h^3\mathrm{Sc}^2 - 585900e^{5\eta}h^3\mathrm{Sc}^2 + 327600e^{3\eta}h^3M\mathrm{Sc}^2 - 974400e^{4\eta}h^3M\mathrm{Sc}^2 - 365400e^{5\eta}h^3M\mathrm{Sc}^2 + 30240e^{2\eta}h^3\mathrm{Sc}^3 - 163800e^{3\eta}h^3\mathrm{Sc}^3 + 243600e^{4\eta}h^3\mathrm{Sc}^3 + 126000e^{5\eta}h^3\mathrm{Sc}^3 + 3628800e^{4\eta}h\mathrm{Sc}\beta + 2721600e^{5\eta}h\mathrm{Sc}\beta + 30240e^{2\eta}h^2\mathrm{Sc}\beta + 378000e^{3\eta}h^2\mathrm{Sc}\beta$$

..(34)

Discussion and result

It's clear that all figure (1-11) are drawn for explain the influence the radiation parameter *Rd* and numbers Biot γ Prandtl pr , Schmidt Sc , stretching ratio , Magnatic parameter M , thermophoretic parameter τ, on temperature concentration.

<u>Effect γ, pr, β, Rd on temperature</u>

Figs (1) illustrate the affected of parameter Rd on temperature . Instances pr= 0.7 and the parameter β =0.3, M =0.5, we note that as *Rd* increase, the temperature increase. Figs (2) illustrate the temperature with impact parameter γ , its noted with Increase in γ the temperature increase . Figs(3**)** show effect β when γ = 0.4 , h= - 1.4 , Pr = 0.7 , Rd = 0.3 , M = 0.5 onto temperature

It's clear that the temperature is decrease with increase β. Observed in Fig (4) increase pr leads to decreased temperature .

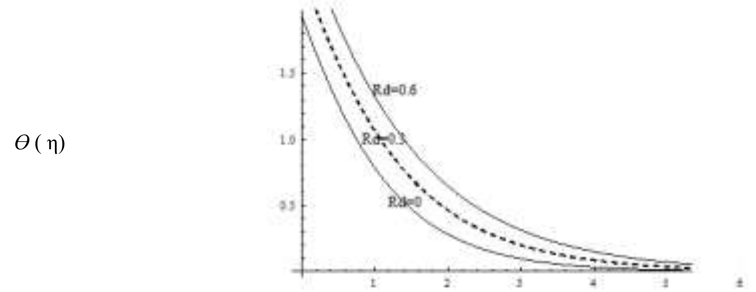

Fig1: Influence the radiation parameter Rd on temperature when γ =0.4,h=-1.4,pr= 0.7, β =0.3,Rd=0,0.3,0.6,M=0.5

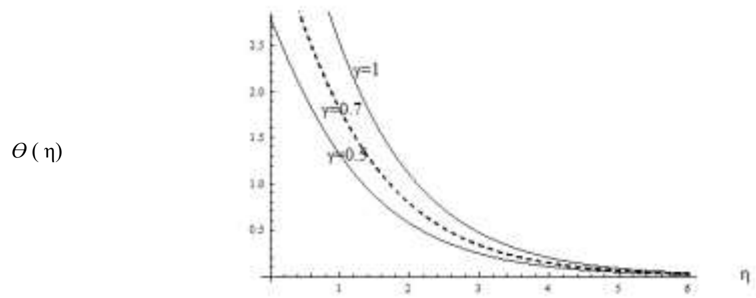

Fig2: Influence the Biot parameter on temperature ,γ =0.5,0.7,1,h=-1.4,pr =0.7, β =0.3,Rd=0.3 ,M=0.5

Θ (η)

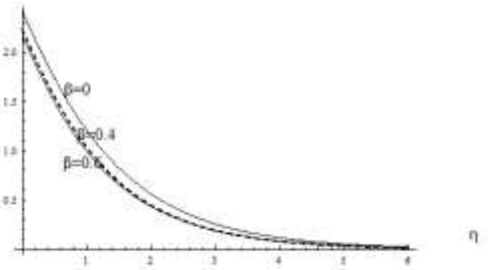

Fig3: Influence the stretching ratio on temperature , γ =0.4,h=-1.4,Pr = 0.7, β =0,0.4,0.6 ,Rd=0.3 ,M =0.5

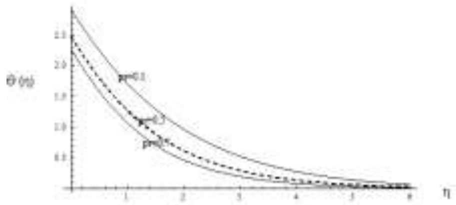

Fig4: Influence Prandtle parameter on temperature , γ = 0.4 , h = ¯1.4, pr = 0.1 , 0.5, 0.7 , Rd = 0.3, β = 0.3 , M = 0.5

effect γ , $\boldsymbol{Rd}$, τ , $\boldsymbol{\beta}$, pr , M ,Sc onto Concentration

All figures(5-11) indicated the concentration affected by parameters γ , M , β , Rd , τ , Pr, Sc when γ =[0.5,0.7,1], β =[0.3,0.7,1],

pr=[1,2,3], Rd=[0.5 ,0.7,1], M=[0.5,1,2], τ=[0.2,0.5,1], sc=[0,0.5,0.7]. In Fig(5) its observed that at increase pr the concentration are

increase .Fig (6)its observed that with increase of Rd from 0.5 to 1the concentration increase , when $\eta\ < 2$,For $\eta\ > 2$ the

concentration start to decrease. In Fig (7) the concentration are decrease with the variant sc from 0to 0.7 . I n fig 8 its noted that

when m increases ,the concentration decreases this similar in fig(7) .fig 9 explain effect β on the concentration when β =0.3,0.7,1 , its clear from the increase in β make the concentration increase. Fig10 is drawn to explain the effect τ on the concentration when τ = 0.2,0.5,1, its noted that at τ increase the concentration decrease .In fig 11 effect γ on the concentration is similar to fig 10 .

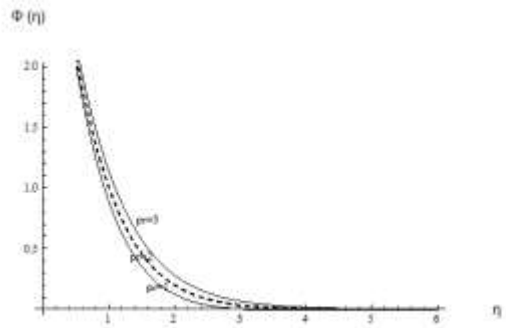

Fig5: Influence Prandtle parameter on concentration when γ= 1,h=-1.4,Pr =1,2,3, β =0.5,Rd=1 ,M =1, τ =1,Sc=1

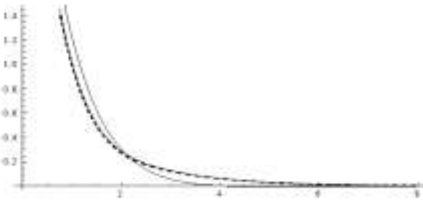

Fig6: Influence radiation parameter on concentration when Rd = 0.5, 0.7 , γ = 0.7,h = −1.4 ,Pr = 1, β = 0.7 , M = 0.5, τ = 1 , Sc = 1

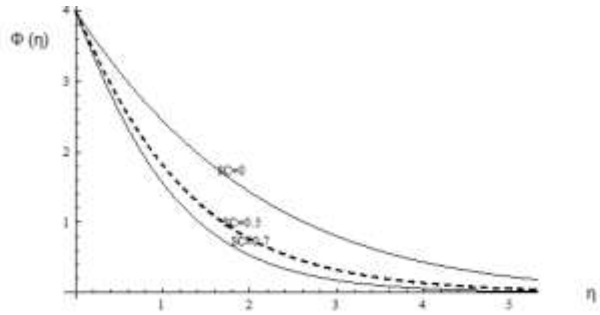

Fig7: Influence Schmidt parameter on concentration when γ = 0.4,h = -1.4, Rd = 0.3, β = 0.3, pr = 0.7 , M =0.5, τ =0.2,Sc=0,0.5,0.7

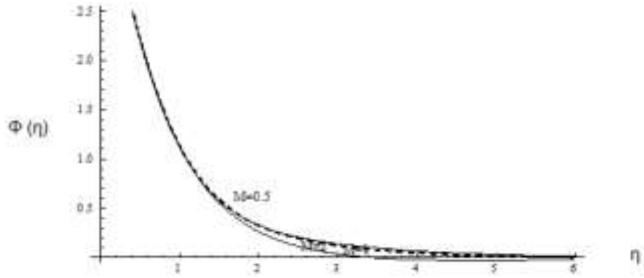

Fig8: Influence magnetic parameter on concentration when γ= 1,h=-1.4,Pr =1, β =0.7,Rd=1,M =0.5,1,2, τ =0.2,Sc=1

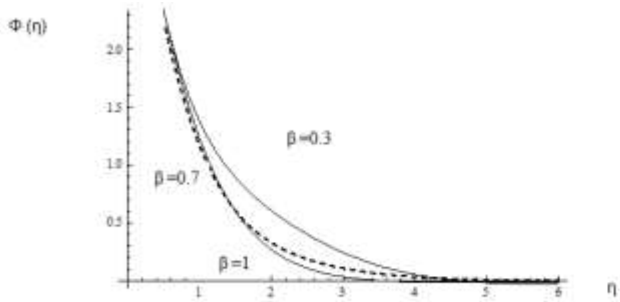

Fig9: Influence stretching ratio parameter on concentration when γ=1,h=-1.4,Pr =1, β =0.3,0.7,1,Rd=1,M =1.3, τ =0.1,Sc=1

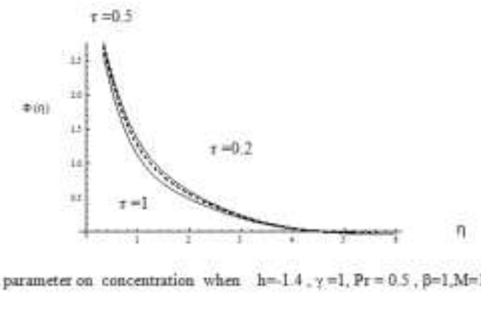

Fig10: Influence thermophoretic parameter on concentration when h=-1.4 , γ =1, Pr = 0.5 , β=1,M=1.3 ,τ = 0.2 , 0.5 , 1 , Sc=1

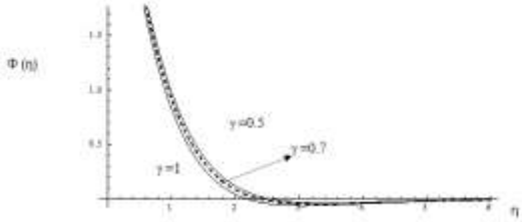

Fig11: Influence the Biot parameter on concentration when $\gamma = 0.5, 0.7, 1, h=-1.4, pr = 0.7, \beta = 0.3, Rd=0.3, M=0.5, \epsilon=2, Sc=1$

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