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Advances in Applied Science Research, 2012, 3 (6):3459-3468

ISSN: 0976-8610
CODEN (USA): AASRFC

Thermosolutal Convection in Compressible, Rotating Couple-Stress Fluid in The Presence of Magnetic Field

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ABSTRACT

The effect of uniform vertical magnetic field and uniform vertical rotation on thermosolutal convection in a layer of an electrically conducting couple-stress fluid heated and soluted from below is considered. For the case of stationary convection, it is clear that stable solute gradient, magnetic field, couple-stress postpone the onset of the convection, where as rotation hastens the onset of convection in compressible, couple-stress fluid heated from below in the presence of a magnetic field. Graphs have been plotted by giving numerical values to the parameters to depict the stability characteristics. Further, the solute gradient, magnetic field, rotation is found to introduce oscillatory modes in the systems that were non-existent in their absence. The sufficient conditions for the non-existence of overstability are also obtained.

Key Words: Thermosolutal Convection, Couple-Stress Fluid, Uniform Vertical Magnetic Field and Uniform Vertical Rotation.

INTRODUCTION

The thermal instability of a fluid layer with maintained adverse temperature gradient when heated from below, plays an important role in geophysics, interior of the earth, oceanography and atmospheric physics etc. The use of Boussinesq approximation has been made throughout, which states that the density may be treated as constant in all the terms in the equation of motion except the external force term. The theoretical and experimental results on thermal convection in a fluid layer, in the absence and presence of magnetic field or rotation has been given by Chandrasekhar (1981). Vernonis (1965) has investigated the problem of thermohaline convection in a layer of fluid heated from below and subjected to a stable salinity gradient. Brakke (1955) explained a double-diffusive instability that occurs when a solution of a slowly diffusing protein is layered over a denser solution of more rapidly diffusive sucrose. Nason et al. (1969) found that this instability which is deleterious to certain biochemical separations can be suppressed by rotation in the ultra centrifuge.

The theory of couple stress fluid has been formulated by Stoke's (1966). Wallicki and Walicka (1999) have modelled synovial fluid as a couple-stress fluid in human joints. One of the applications of couple- stress fluid is its use to the study of the mechanisms of lubrications of synovial joints, which has become the object of scientific research. A human joint is a dynamically loaded bearing which has articular cartilage as the bearing and the synovial fluid as the lubricant. When a fluid is generated, squeeze – film action is capable of providing considerable protection to the cartilage surface. The shoulder, ankle, knee and hip joints are the loading – bearing synovial joints of the human body and these joints have a low friction coefficient and negligible wear. Normal synovial fluid is clear or yellowish and is a viscous, non-Newtonian fluid. According to the theory of Stoke's (1966), couple-stresses are found to appear in noticeable magnitudes in fluids with very large molecules. The long chain hyaluronic acid molecules are found as additives in synovial fluids. Wallicki and Walicka (1999) have studied the effects of couple-stresses and inertia effects on the characteristics of squeeze-film behaviour in the thrust curvilinear bearings with references to synovial joints. On the basis of Stoke's couple-stress fluid model, Wallicki and Walicka (1999) have made mathematical modelling of some biological bearings.

Darcy's law governs the flow of Newtonian fluid through isotropic and homogeneous porous medium. However, to be mathematically compatiable and physically consistent with the Navier-stokes equations, Brinkman (1949) heuristically proposed the introduction of the term $\frac{\mu}{\varepsilon}\nabla^2 \vec{q}$ (now known as Brinkman term) in addition to Darcian term $-\left(\frac{\mu}{k_1}\right)\vec{q}$. But the main effect is through Darcian term and the Brinkman term contributes a very little effect, for flow through porous medium. Therefore, Darcy's law is proposed to govern the flow of this non-Newtonian couple-stress fluid. Sharma and Chandel (2002), have studied on superposed couple-stress fluids in porous medium in hydrodynamics and pardeep et al. (2004,2007), have studied couple-stress fluid with rotation and double-diffusion without and with porous medium have found very useful and effective results. In another study Kumar and Singh (2009,2009,2011, 2012) have been found useful results, in their research.

Keeping in mind the importance of non-Newtonian fluids, like the themosolutal convection and compressibility, the present study considers a layer of compressible couple –stress fluid heated from below in the presence of uniform magnetic field and rotation.

2. Formulation of the Problem and Perturbation Equations

Here we consider an infinite , horizontal, incompressible, electrically conduction couple-stress fluid layer of thickness d, heated from below so that, the temperatures and densities at the bottom surface z = 0 are T_o and ρ_o and at the upper surface z = d are T_d and ρ_d respectively and that a uniform temperature gradient $\beta (= |dT/dz|)$ is maintained. The gravity field $\vec{g}$ = (0, 0, -g), a uniform vertical magnetic field $\vec{H}$ = (0, 0, H) and a uniform vertical rotation $\vec{\Omega} = (0,0,\Omega)$ act on the system.

The initial state is, therefore a state in which the fluid velocity, temperature, pressure, solute concentration and density at any point in the fluid are given by $\vec{q} = 0$, T = T (z), p = p(z), C = C(z), ρ = ρ(z), respectively, where

$T(z) = T_m - \beta z$

$p(z) = p'_m - g \int_0^z (\rho_m + \rho'_m)\, dz,$

$C = C_0 - \beta' z$,

$$\rho(z) = \rho_m[1-\alpha_m(T-T_m)+K_m(p-p_m)+\alpha'(C-C_m)] \tag{2.1}$$

and $\alpha_m = -\left(\frac{1}{\rho}\frac{\partial\rho}{\partial T}\right)_m$, (= α say) $\alpha'_m = -\left(\frac{1}{\rho}\frac{\partial\rho}{\partial C}\right)_m$, (= α′ say)

$$K_m = \left(\frac{1}{\rho}\frac{\partial\rho}{\partial p}\right)_m \tag{2.2}$$

Let $\vec{q}$ = (u, v, w), δp, δρ, θ, γ, $\vec{h}(h_x, h_y, h_z)$ denotes respectively the perturbations in velocity (0,0,0),pressure p, density ρ, temperature T, solute concentration C and magnetic field $\vec{H}(0,0,H)$. Then the linearized perturbation equations, relevant to the problem are given by

$$\frac{\partial\vec{q}}{\partial t} = -\frac{1}{\rho_m}\nabla\delta p - g(\alpha\theta - \alpha'\gamma) + \left(\nu - \frac{\mu'}{\rho_m}\nabla^2\right)\nabla^2 q + 2(\vec{q}\times\Omega) + \frac{\mu_e}{4\pi\rho_m}(\nabla\times\vec{h})\times\vec{H}, \tag{2.3}$$

$$\nabla\cdot\vec{q} = 0, \tag{2.4}$$

$$\frac{\partial\theta}{\partial t}=\left(\beta-\frac{g}{c_p}\right)w+\kappa\nabla^2\theta, \tag{2.5}$$

$$\frac{\partial\gamma}{\partial t}=\beta^{/}w+\kappa^{/}\nabla^2\gamma \tag{2.6}$$

$$\nabla\cdot\vec{h}=0 \tag{2.7}$$

$$\frac{\partial\vec{h}}{\partial t}=\left(\vec{H}\cdot\nabla\right)\vec{q}+\eta\nabla^2\vec{h} \tag{2.8}$$

$$\delta\rho=-\rho_m\left(\alpha\theta-\alpha^{/}\gamma\right), \tag{2.9}$$

Where ν , $\mu^{/}$ c_p, κ, $\kappa^{/}$ and $\frac{g}{c_p}$ stands for kinematic viscosity, couple-stress viscosity, specific heat at constant pressure, thermal diffusivity and adiabatic gradient respectively. The equation of the state is

$$\rho=\rho_m[1-\alpha\ (T-T_m)+\alpha^{/}(C-C_m)]\ . \tag{2.10}$$

The above equation contains the thermal coefficient of expansion α and an analogous solute coefficient $\alpha^{/}$, as the density primarily depends upon temperature and solute concentration, the change in density $\delta\rho$ caused by the perturbation θ and γ is given by

$$\delta\rho=-\rho_m\left(\alpha\theta-\alpha^{/}\gamma\right), \tag{2.11}$$

Solving equation in form of scalar components and using the of equation (2.4), we have

$$\frac{\partial}{\partial t}\left(\frac{\partial^2 w}{\partial z^2}\right)=\frac{1}{\rho_m}\frac{\partial}{\partial z}\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\delta p+\left(\nu-\frac{\mu^{/}}{\rho_m}\nabla^2\right)\nabla^2\left(\frac{\partial^2 w}{\partial z^2}\right)\ -2\Omega\frac{\partial\zeta}{\partial z}+\frac{\mu_e H}{4\pi\rho_m}\frac{\partial}{\partial z}\left(\nabla^2 h_z\right) \tag{2.12}$$

Where $\zeta=\left(\frac{\partial v}{\partial x}-\frac{\partial u}{\partial y}\right)$.

At a rigid surface u = 0, v = 0, w = 0 on a rigid surface for all x and y

therefore equation of continuity reduces to

$$\frac{\partial w}{\partial z}=0\ \text{ or }\ \ \nabla w=0 \tag{2.13}$$

$$\Rightarrow\frac{1}{\rho_m}\frac{\partial}{\partial z}\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\delta p=g\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\left(\alpha\theta-\alpha^{/}\gamma\right) \tag{2.14}$$

By using equation (2.14), the equation (2.12) becomes

$$\frac{\partial}{\partial t}\left(\nabla^2 w\right)-g\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\left(\alpha\theta-\alpha^{/}\gamma\right)-\left(\nu-\frac{\mu^{/}}{\rho_m}\nabla^2\right)\nabla^4 w+2\Omega\frac{\partial\zeta}{\partial z}-\frac{\mu_e H}{4\pi\rho_m}\frac{\partial}{\partial z}\nabla^2 h_z=0. \tag{2.15}$$

Operating equations (2.4) to (2.11) also yield

$$\frac{\partial\zeta}{\partial t}-\left(\nu-\frac{\mu^{/}}{\rho_m}\nabla^2\right)\nabla^2\zeta=2\Omega\frac{\partial w}{\partial z} \tag{2.16}$$

$$\left(\frac{\partial}{\partial t}-k\nabla^2\right)\theta=\left(\beta-\frac{g}{c_p}\right)w \tag{2.17}$$

$$\left(\frac{\partial}{\partial t}-k^{/}\nabla^2\right)\gamma=\beta^{/}w \tag{2.18}$$

$$\left(\frac{\partial}{\partial t}-\eta\nabla^2\right)h_z = H\frac{\partial w}{\partial z} \tag{2.19}$$

3. The dispersion relations

Analyzing the disturbances into normal modes, we assume that the perturbation quantities are of the form

$$[w,\theta,\gamma,\varsigma,h_z] = [W(z),\Theta(z),\Gamma(z),Z(z),K(z)]\exp(ik_x x + ik_y y + nt) \tag{3.1}$$

Where k_x and k_y are wave numbers along x and y directions respectively k = $\sqrt{k_x^2+k_y^2}$ is the resultant wave number , n a complex constant putting x = x$^{/}$d, y = y$^{/}$d, z = z$^{/}$d, D = $\frac{d}{dz}$, a = kd, $\sigma = \frac{nd^2}{\nu}$, $\frac{\partial}{\partial t} = n$,

$$\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2} = -k^2,\ \nabla^2 = \frac{d^2}{dz^2}-k^2 \ . \tag{3.2}$$

Equation (2.15) - (2.19) becomes

$$n\left(\frac{d^2}{dz^2}-k^2\right)w - g(-k^2)(\alpha\Theta-\alpha^{/}\Gamma) - \left[\nu - \frac{\mu^{/}}{\rho_m}\left(\frac{d^2}{dz^2}-k^2\right)\right]$$

$$\left(\frac{d^2}{dz^2}-k^2\right)^2 w + 2\Omega\frac{dZ}{ddz^{/}} - \frac{\mu_e H}{4\pi\rho_m}\frac{d}{ddz^{/}}\left(\frac{d^2}{dz^2}-k^2\right)K = 0, \tag{3.3}$$

$$nZ - \left[\nu - \frac{\mu^{/}}{\rho_m}\left(\frac{d^2}{dz^2}-k^2\right)\right]\left(\frac{d^2}{dz^2}-k^2\right)Z = 2\Omega\frac{dW}{ddz^{/}}\ , \tag{3.4}$$

$$\left[n - K\left(\frac{d^2}{dz^2}-k^2\right)\right]\Theta = \left(\beta - \frac{g}{c_p}\right)w\ , \tag{3.5}$$

$$\left[n - k^{/}\left(\frac{d^2}{dz^2}-k^2\right)\right]\Gamma = \beta^{/}w, \tag{3.6}$$

$$\left[n - \eta\left(\frac{d^2}{dz^2}-k^2\right)\right]K = H\frac{d}{ddz^{/}}w, \tag{3.7}$$

Also z = dz$^{/}$ $\Rightarrow$ dz = d dz$^{/}$ $\Rightarrow$ $\frac{d}{dz} = \frac{1}{ddz^{/}} = \frac{D}{d}$.

Where D = $\frac{d}{dz^{/}}$ and $(dz)^2 = d^2\,(dz^{/})^2$,

$$\Rightarrow \frac{d^2}{dz^2} = \frac{d^2}{d^2(dz^{/})^2} = \frac{D^2}{d^2} \text{ and } k^2 = \frac{a^2}{d^2}\ , \tag{3.8}$$

using equation (3.8), equations, (3.3), (3.5), (3.6) and (3.7), becomes

$$[\{1 - F(D^2-a^2)\}(D^2-a^2) - \sigma]Z = -\frac{T_A^{1/2}}{d}Dw, \tag{3.9}$$

$$[D^2 - a^2 - p_1\sigma]\Theta = -\left(\frac{G-1}{G}\right)\frac{\beta d^2}{k}W\ , \tag{3.10}$$

$$[D^2 - a^2 - q\sigma]\Gamma = -\frac{\beta^{/}d^2}{k^{/}}W\ , \tag{3.11}$$

$$[D^2 - a^2 - p_2\sigma]K = -\left(\frac{Hd}{\eta}\right)DW, \tag{3.12}$$

Where F = $\frac{\mu'}{\nu\rho_m d^2}$ is dimensionless couple-stress parameter

$T_A = \frac{4\Omega^2 d^4}{\nu^2}$ is the Taylor number

G = $\frac{\beta c_p}{g}$, is the dimensionless compressibility parameter and $p_1 = \frac{\nu}{\kappa}$ is the Prandtl number, $q = \frac{\nu}{k'}$, is the Schmidt number and $p_2 = \frac{\nu}{\eta}$, is Prandtl number.

Now eliminating Θ, K, Z, Γ, between equations (3.9)-(3.12) ,we get

$$[\{1-F(D^2-a^2)](D^2-a^2)^2W + Q(D^2-a^2-p_1\sigma)(D^2-a^2-q\sigma)(D^2-a^2)$$
$$[\{1-F(D^2-a^2)\}(D^2-a^2)-\sigma]D^2W = 0 \tag{3.13}$$

Where $R = \frac{g\alpha\beta d^4}{\nu k}$ is the Rayleigh number, $S = \frac{g\alpha'\beta' d^4}{\nu k'}$ is the solute Rayleigh number, $Q = \frac{\mu_e H^2 d^2}{4\pi\rho_m \eta\nu}$ is the Chandrasekhar number.

Consider the case in which both the boundaries are free and are maintained at constant temperature. The transformed non-dimensional boundary conditions appropriate to the problem are

$$W = D^2W = D^4W = 0,\ \Theta = 0,\ \Gamma = 0,\ DK = 0 \text{ and } DZ = 0 \text{ at } z = 0 \text{ and } z = 1. \tag{3.14}$$

Hence the proper solution of W characterizing the lowest mode is

$$W = W_0 \sin \pi z, \tag{3.15}$$

where W_0 is a constant .

Putting $D^2 = -\pi^2$ in (3.13) and using equation (3.15) we get

$$R_1 = \left(\frac{G-1}{G}\right)\frac{\begin{aligned}&[i\sigma_1(1+x)(1+x+ip_1\sigma_1)(1+x+ip_2\sigma_1)(1+x+iq\sigma_1)[\{1+F_1(1+x)\}(1+x)+i\sigma_1] + S_1x(1+x+ip_1\sigma_1)(1+x+ip_2\sigma_1)[\{1+F_1(1+x)\}(1+x)+i\sigma_1]\\ &+ T_1(1+x+ip_1\sigma_1)(1+x+iq\sigma_1)(1+x+ip_2\sigma_1) + (1+x+ip_1\sigma_1)(1+x+ip_2\sigma_1)(1+x+iq\sigma_1)[\{1+F_1(1+x)\}(1+x)+i\sigma_1][1+F_1(1+x)](1+x)^2\\ &+ Q_1(1+x)(1+x+ip_1\sigma_1)(1+x+iq\sigma_1)[\{1+F_1(1+x)\}(1+x)+i\sigma_1]\end{aligned}}{x(1+x+ip_2\sigma_1)(1+x+iq\sigma_1)[\{1+F_1(1+x)\}(1+x)+i\sigma_1]} \tag{3.16}$$

where $R_1 = \frac{R}{\pi^4}$, $S_1 = \frac{S}{\pi^4}$, $F_1 = \pi^2 F$, $T_1 = \frac{T_A}{\pi^4}$ and $i\sigma_1 = \frac{\sigma}{\pi^2}$, $Q_1 = \frac{Q}{\pi^2}$ and $x = \frac{a^2}{\pi^2}$,

4. The stationary convection

When the instability sets in stationary convection, the marginal state will be characterized by $\sigma_1 = 0$. Putting $\sigma_1 = 0$ the dispersion relation (3.16) reduces to

$$R_1 = \frac{\left(\frac{G}{G-1}\right)\left[(1+x)^3[1+F_1(1+x)]^2 + S_1x[1+F_1(1+x)] + Q_1(1+x)[1+F_1(1+x)] + T_1\right]}{x[1+F_1(1+x)]} \tag{4.1}$$

Equation (4.1) expresses the modified Rayleigh number R_1 as a function of the dimensionless wave number x and the parameters G, F_1, S_1, Q_1, T_1. For fixed F_1, S_1, Q_1, T_1, let G (accounting for the compressibility effects) also be kept fixed. Then we find that

$$\overline{R}_c = \left(\frac{G}{G-1}\right) R_c \tag{4.2}$$

Where $\overline{R}_c$ and R_c denotes respectively the critical Rayleigh numbers in the presence and absence of compressibility. G > 1 is relevant here. The case G< 1 and G = 1 corresponds to negative and infinite values of the critical Rayleigh number in the presence of compressibility, which are not relevant in the present study.

The effect of compressibility is, therefore, to postpone the onset of thermosolutal convection and so has a stabilizing effect.

To study the effects of stable solute gradient, magnetic field, couple-stress parameter and rotation, we examine the nature of $\frac{dR_1}{dS_1}$, $\frac{dR_1}{dQ_1}$, $\frac{dR_1}{dF_1}$ and $\frac{dR_1}{dT_1}$ analytically, equation (4.1) yields

$$\frac{dR_1}{dS_1} = \left(\frac{G}{G-1}\right) \tag{4.3}$$

$$\frac{dR_1}{dQ_1} = \left(\frac{G}{G-1}\right)\left(\frac{1+x}{x}\right) \tag{4.4}$$

$$\frac{dR_1}{dF_1} = \frac{\left(\frac{G}{G-1}\right)(1+x)[(1+x)^3\{1+F_1(1+x)\}^2 - T_1]}{x[1+F_1(1+x)]^2} \tag{4.5}$$

$$\frac{dR_1}{dT_1} = \frac{\left(\frac{G}{G-1}\right)}{x[1+F_1(1+x)]} \tag{4.6}$$

From equations (4.3) to (4.6) it is clear that stable solute gradient, magnetic field, couple –stress postpone the onset of the convection. Whereas rotation hastens the onset of convection in compressible, couple-stress fluid heated from below in the presence of a magnetic field.

It is evident from equation, (3.16) and equation (4.1) for a stationary convection the magnetic field and the couple stress postpone the onset of convection in the presence of rotation if $T_1 < x\,[1 + F_1(1 + x)]$. Whereas the magnetic field and couple stress hastens the onset of convection if $T_1 > x\,[1 + F_1(1 + x)]$.

Now analysing the equation (4.1) graphically,

In Fig 1: R_1 is plotted against x for T_1 = 100, 200, 300, F_1 = 2, G =10, Q_1 = 10 and S_1 = 10. It is clear that rotation postpones the onset of convection in a couple stress fluid heated from below in the presence of magnetic field as the Rayleigh number increases with an increase in rotation parameter.

In Fig 2: R_1 is plotted against x for Q_1 = 10, 30, 50, F_1 = 2, G =10, T_1 = 100 and S_1 = 10. Here we find that the magnetic field postpones the onset of convection in the presence of rotation for all wave numbers as the Rayleigh number increases with increase in the magnetic field parameter.

In Fig 3: R_1 is plotted against x for F_1 = 2, 4, 6, Q_1 = 100, G =10, T_1 = 1 and S_1 = 10. Here we find that couple-stress hastens the onset of convection in the presence of rotation for small wave numbers as the Rayleigh number decreases with the increase in couple- stress parameter and postpones the onset of convection in the absence of rotation for high wave numbers.

In Fig 4: R_1 is plotted against x for S_1 = 10, 30, 50, Q_1 = 10, G =10, T_1 = 100 and F_1 = 2. Here we observe that stable solute gradient postpones the onset of convection in a couple stress fluid heated from below in the presence of magnetic field and rotation as the Rayleigh number increases with the increase in rotation parameter.

In Fig 5, R_1 is plotted against x for G = 10, 30, 50, Q_1 = 100, S_1 =10, T_1 = 100 and F_1 = 2. Here we find that with the increase of wave number there is increase in Rayleigh number thus indicating the stabilizing effect with the increase of compressibility.

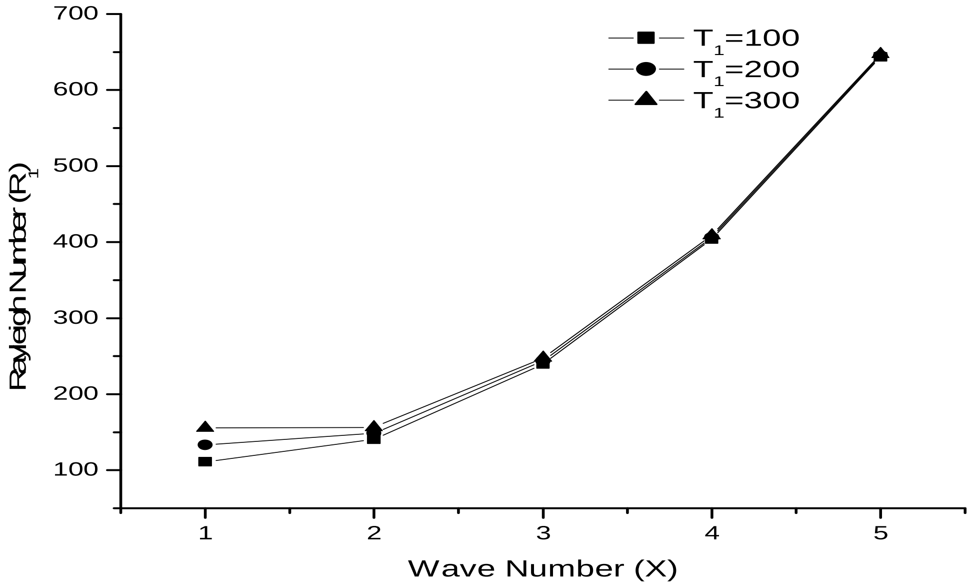

Fig.1: Variation of Rayleigh Number (R_1), with wave number(X=1-5), for T_1(=100, 200, 300),F_1=2,Q_1=10,S_1=10 and G=10.

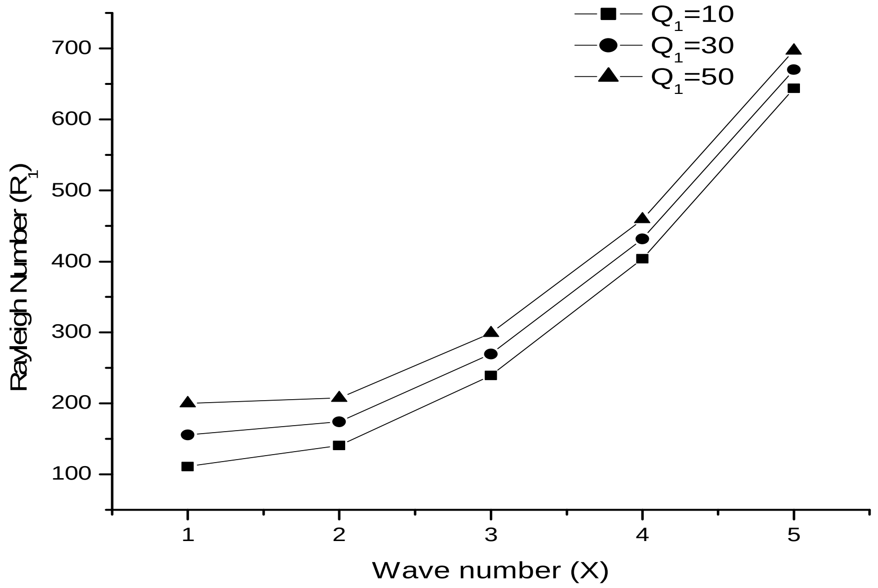

Fig.2: Variation of Rayleigh Number(R_1), with wave number X(=1-5),for Q_1(10,30,50),when T_1=100,F_1=2,S_1=10 and G=10.

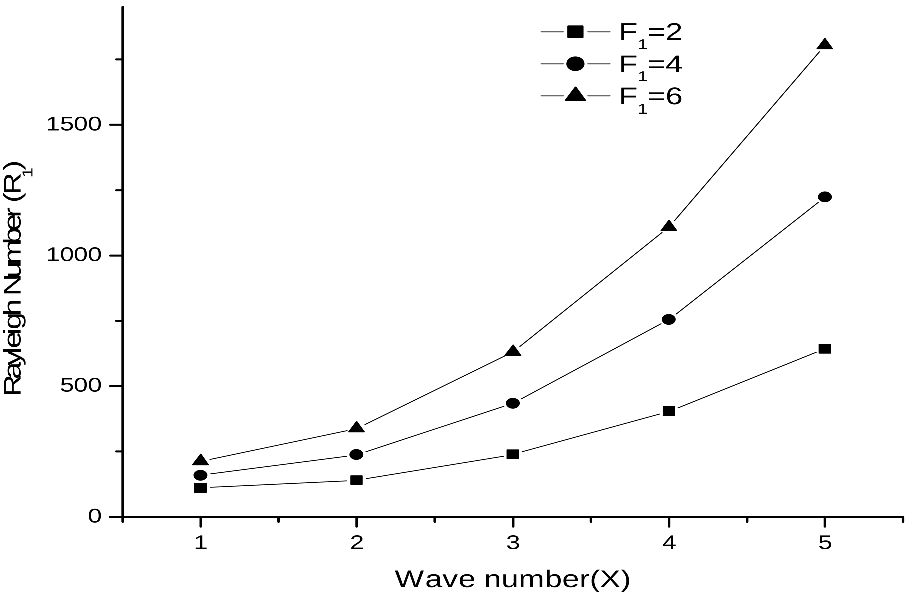

Fig.3: Variation of Rayleigh Number (R_1),with wave number X(=1-5),for F_1(=2,4,6), when T_1=100,Q_1=10,S_1=10 and G=10.

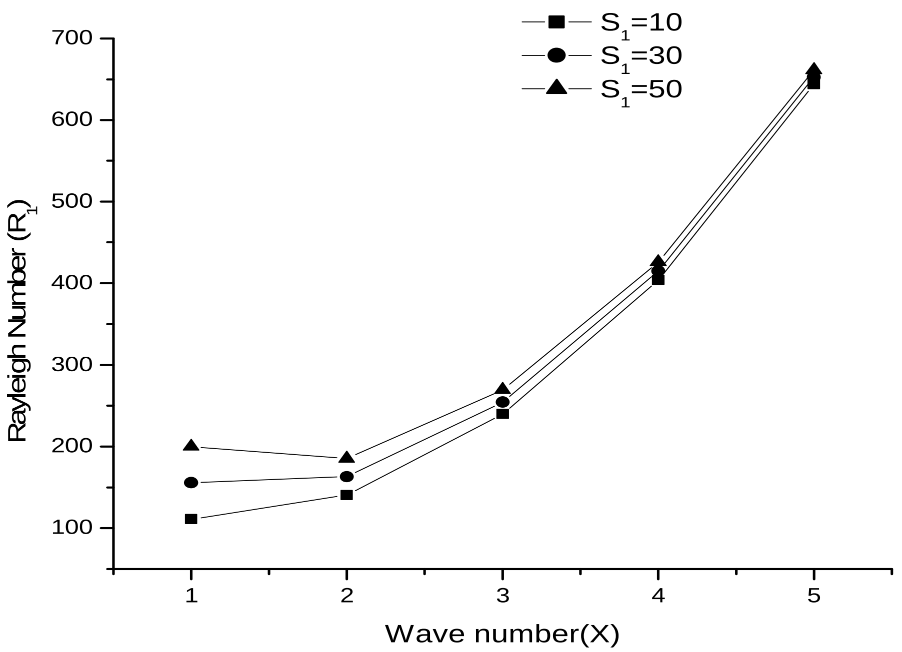

Fig.4: Variation of Rayleigh Number (R_1),with wave number X(=1-5),for S_1(=10,20,30),when T_1=100,Q_1=10.S_1=10 and G=10.

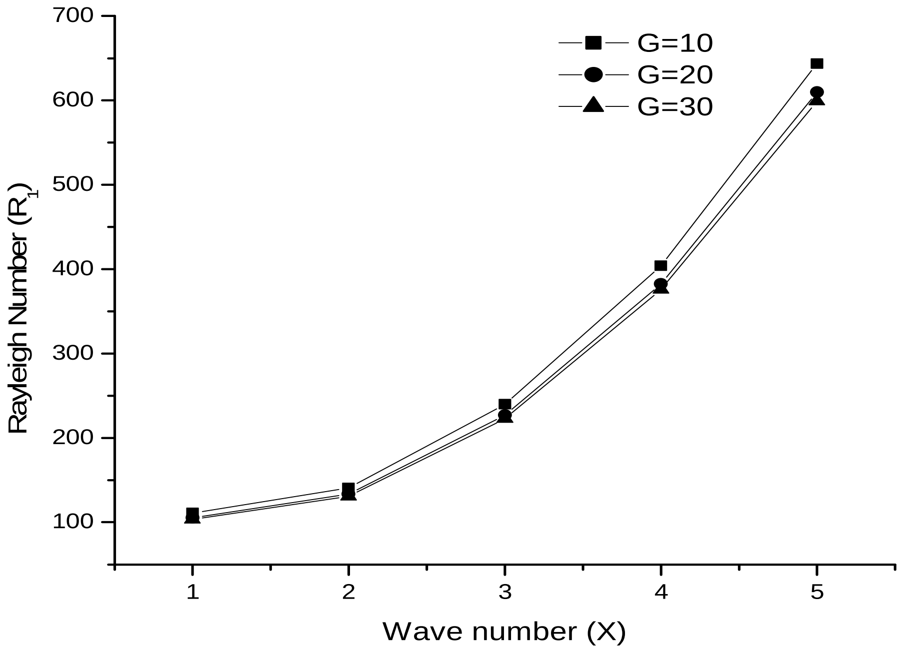

Fig.5: Variation of Rayleigh Number (R_1),with wave number X(=1-5),for G(=10,20,30),when T_1=100,Q_1=S_1=G=10.

5. The case of overstability

Here we discuss the possibility of whether instability may occur as overstability. Since for overstability, we wish to determine the critical Rayleigh number for the onset of instability , a state of pure oscillations, it suffices to find conditions for which equation (3.16) will admit of solutions with σ_1 real by equating real and imaginary parts of equation (3.16) and eliminating R_1 between them, we get

$$A' C^3 + B' C^2 + C' C + D' = 0 \tag{5.1}$$

Where: $1+ x = b$, $\sigma_1^2 = c$ and $(1 + F_1 b) = A_1$,

$$A' = b^2 p_2^2 q^2 + b^2 p_1 p_2^2 q^2 (1 + F_1 b)$$

$$B' = b^4 q^2 (1 + F_1 b)^2 + b^4 p_1 p_2^2 q^2 (1 + F_1 b)^3 + b^4 p_1 p_2^2 (1 + F_1 b) + b^4 (p_2 + q)^2 + b^4 p_1 q^2 (1 + F_1 b) + b^6 - b^4 p_2 q + S_1 x p_1 p_2 b (p_2 - q) + bq (p_1 - p_2^2) + T_1 b \, p_2^2 q^2 [(p_1 - 1) + p_1 F_1 b] + Q_1 b^2 q^2 (p_1 - p_2)]$$

$$C' = b^6[(T_1 - 1) + p_1 F_1 b] + b^6 p_2^2 (1 + F_1 b)^2 + 2 b^6 p_2 q + b^6 q^2 + b^6 p_1 p_2^2 (1 + F_1 b)^3 + b^6 p_1 q^2 (1 + F_1 b)^3 - 2 b^6 p_2 q (1 + F_1 b)^2 + S_1 x [b^3 (p_1 - q) + b^3 p_1 p_2^2 (1 + F_1 b)^2] + T_1 [b^3 (p_2^2 + q^2)(p_1 - 1) + p_1 F_1 b^4 (p_2^2 + q^2)] + Q_1 b^4 [q^2 (1 + F_1 b)^2 + 1] (p_1 - p_2)$$

$$D' = b^8 (1+ F_1 b)^2 + b^8 p_1 (1 + F_1 b)^3 + S_1 x [b^5 (1 + F_1 b)^2 (p_1 - q)] + T_1 [b^5 (p_1 - 1) + b^6 p_1 F_1] + Q_1 [b^6 (1 + F_1 b)^2 (p_1 - p_2)]$$

It is evident from the equation (5.1) that if $p_1 > 1$ that is if $\kappa < \nu$, is therefore a sufficient condition for the non-existence of overstability, the violation of which does not necessarily imply the occurrence of overstability, the sufficient condition $\kappa < \nu$ for the non existence of overstability is found to be the same for compressible, couple stress fluid as well as for incompressible, Newtonian fluid (Chandrasekhar, 1981) in presence of rotation, magnetic field and heated from below.

It is also evident from the equation (5.1) that $p_1 > p_2$ thus implying $\frac{\nu}{\kappa} > \frac{\nu}{\eta}$ that is if $\kappa < \eta$ is therefore, a sufficient condition for the non-existence of overstability, the violation of which does not necessarily imply the occurrence of overstability. The sufficient condition for the non existence of overstability is found to be the same for compressible, couple stress fluid as well as for incompressible Newtonian fluid (Chandrasekhar, 1981) in presence of rotation, magnetic field and heated from below.

CONCLUSION

In the present paper, thermosolutal convection in compressible, rotating couple-stress fluid in the presence of magnetic field has been considered and found that for the case of stationary convection, it is clear that stable solute gradient, magnetic field, couple-stress postpone the onset of the convection, where as rotation hastens the onset of convection in compressible, couple-stress fluid heated from below in the presence of a magnetic field. Graphs have been plotted by giving numerical values to the parameters to depict the stability characteristics, and case of overstability results is defined as above.

Acknowledgements
The authors are grateful to the learned referees for their critical and technical comments, which led to significant improvement in the paper.

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