INSTABILITY OF SUSPENDED PARTICLES ON VISCO-ELASTIC ROTATING FLUID FLOW WITH THERMAL CONVECTION

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Abstract –
In this paper, the instability of suspended particles and rotation on viscoelastic fluid layer heated from below saturating a porous medium in the presence of uniform vertical magnetic field has been investigated. The dispersion relation was obtained using the normal mode and the problem has been numerically analyzed by MATLAB. The effect of medium permeability, magnetic field, suspended particles and rotation have been obtained and the effect of suspended particle on the system is very important result. The condition of over stability is also obtained.

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Keywords - Thermal Convection, Visco-elastic Fluid, Suspended Particle, Porous Medium and Rotation.

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1 Introduction

2 Mathematical Formulation
A horizontal, infinite and incompressible viscoelastic fluid layer of thickness d is assumed. The lower boundary at z = 0 and upper boundary at z = d are continued at constant but variable temperatures T₀ and T₁ such that an adverse temperature gradient β = (dT/dz) has been maintained. The uniform vertical magnetic field, rotation Ω = (0, 0, Ω) and gravity g = g(0, 0, −g) are applied along z-axis.

The equation of continuity and motion are

\[ \nabla \cdot \vec{q} = 0, \quad (2.1) \]

\[
\frac{\rho_0}{\varepsilon} \left[ \frac{\partial \vec{q}}{\partial t} + \frac{1}{\varepsilon} (\vec{q}, \nabla) \vec{q} \right] = -\nabla P - \frac{1}{k_1} \left( \mu + \mu' \frac{\partial}{\partial t} \right) \vec{q} + \mu \nabla^2 \vec{q} - \rho g \hat{e}_z + \frac{2\rho_0}{\varepsilon} (\vec{q} \times \Omega) + \frac{K N}{\varepsilon} (\vec{q}_d - \vec{q}) + \frac{\mu_e}{4\pi} (\nabla \times \vec{H}) \times \vec{H}, \quad (2.2)\]

where P – Pressure, \( \rho \) – Fluid density, \( \rho_0 \) – Reference density, \( \mu \) – Viscosity, \( \mu' \) – Viscoelasticity, \( \vec{q} \) – Velocity, \( \vec{q}_d(x, t) \) – Velocity of suspended particles, \( \mu_e \) – Magnetic permeability, \( \hat{e}_z \) – Unit vector in z-direction, t – time, N (x, t) – Number density of suspended particles, x = (x, y, z) and \( K = 6\pi \mu r \), r being the particle radius, is the stokes drag coefficient. The equation of energy, basics state and Maxwells equation are
\[ \varepsilon \rho_0 C_v + (1 - \varepsilon) \rho_s C_s \frac{\partial T}{\partial t} + \rho_0 C_v (\vec{q} \cdot \nabla) T + mN C_{pt} \left( \varepsilon \frac{\partial T}{\partial t} + \vec{q}_d \cdot \nabla T \right) = \chi \nabla^2 T. \quad (2.3) \]

\[ \varepsilon \frac{\partial \vec{H}}{\partial t} = \nabla \times \left( \vec{q} \times \vec{H} \right) + \varepsilon \eta \nabla^2 \vec{H}, \quad (2.4) \]

\[ \nabla \cdot \vec{H} = 0, \quad (2.5) \]

\[ \rho = \rho_0 \left[ 1 - \alpha (T - T_a) \right]. \quad (2.6) \]

where \( C_v \) - Specific heat at constant volume, \( H = (0,0,H_z) \), \( C_s \) - Constant, \( C_{pt} \) - Specific heat of suspended particles, \( \eta \) - Magnetic viscosity, \( \rho_s \) - Density of solid matrix, \( T \) Temperature, \( \chi \) - Thermal conductivity, \( \alpha \) - Coefficient of thermal expansion, \( T_a \) - Average temperature is given by \( T_a = \frac{(T_b + T_0)}{2} \).

The equations of motion and continuity for the suspend particles are

\[ mN \left[ \frac{\partial \vec{q}_d}{\partial t} + \varepsilon (\vec{q}_d \cdot \nabla) \vec{q}_d \right] = KN (\vec{q} - \vec{q}_d), \quad (2.7) \]

\[ T = \beta z + T_a = T_b (z), \quad {\text{where}} \quad \beta = \frac{(T_1 - T_0)}{d} \quad \text{and} \quad N = N_0 \quad (3.2) \]

\[ \rho_b = \rho_0 + \beta z \rho_0. \quad (3.3) \]

4 Linearize Perturbation Equations

Now, linearize the equation of (2.1) to (2.8), we have

\[ L \left[ \rho_0 \frac{\partial \vec{q}^0}{\partial t} \right] = L \left[ -\nabla P^0 - \frac{1}{k_1} \left( \mu + \mu' \frac{\partial}{\partial t} \right) \vec{q}^0 + \mu \nabla^2 \vec{q}^0 + \rho_0 \alpha \theta_0 + \frac{2\rho_0}{\varepsilon} \left( \vec{q}^0 \times \Omega \right) + \frac{\mu_0 H_z}{4\pi} \left( \nabla \times \vec{H} \right) \times \mathbb{E}_z - \frac{mN_0}{\varepsilon} \frac{\partial \vec{q}^0}{\partial t} \right], \quad (4.2) \]

\[ L \left[ E + h_T \right] \in \frac{\partial \vec{q}^0}{\partial t} = L \left[ k_T \nabla^2 \vec{q}^0 + \beta (\vec{q}^0) \right] + \mu_T \left( \vec{q}^0 \right), \quad (4.3) \]

\[ \frac{\partial \vec{H}}{\partial t} = H_z \times (\vec{q}^0 \times \mathbb{E}_z) + \varepsilon \nabla^2 \vec{H}, \quad (4.4) \]

\[ \nabla \cdot \vec{H} = 0, \quad (4.5) \]

\[ \rho' = -\rho_0 \alpha \theta. \quad (4.6) \]

where \( k_T = \frac{\chi}{\rho_0 C_v}, h_T = \frac{mN_0 C_{pt}}{\rho_0 C_v} \) are the thermal diffusivity and \( L = \frac{[\rho \varepsilon]}{\rho_0 C_v} + 1 \), \( E = (1 - \varepsilon) \rho_s C_s \). \n
Converting equation (4.1) to (4.6) by the following transformation \( \vec{q} = \frac{b_T}{b} \vec{q}^*, \nabla = \frac{\Omega}{\Omega s}, \Omega = -\frac{\mu}{\rho c} \Omega s, P' = \frac{\mu k_T}{\mu c} P^*, \vec{H} = H_z H^* + t = \frac{k_T}{b} t^*, L = \tau \frac{b}{b^*} + 1 \), \( \tau = \frac{mN_0}{\rho_0 C_v} \) and \( \theta = \beta d T^* \), we have
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\[ L \frac{1}{\nu} \frac{\partial \tilde{q}}{\partial t} = L \left[ -\nabla P - \frac{1}{K_1} \left( 1 + F \frac{\partial}{\partial t} \right) \tilde{q} + R \theta \epsilon_z + \nabla^2 \tilde{q} + \frac{2}{\nu} (\tilde{q} \times \Omega) + Q (\nabla \times \tilde{h}) \times \tilde{e}_z \right] - \frac{f}{\nu} \frac{\partial \tilde{q}}{\partial t}, \quad (4.7) \]

\[ LP_r E_r \frac{\partial \theta}{\partial t} = L \left[ \nabla^2 \theta + (\tilde{q})_z \right] + h_T (\tilde{q})_z, \quad (4.8) \]

\[ \in P_r \frac{\partial \tilde{h}}{\partial t} = \frac{\partial \tilde{q}}{\partial z} + \in P_m \nabla^2 \tilde{h}, \quad (4.9) \]

where \( Q = \frac{\mu_s \nu^2 d^2}{4 \pi \mu_0} \) - Chandrasekhar number, \( R = \frac{\rho \partial}{\nu \partial t} \) - Thermal Rayleigh number, \( F = \frac{\mu'}{\rho \nu d^2} \) - Viscoelastic Parameter, \( P_r = \frac{\mu}{\kappa T \rho_0} \) - Prandtl number, \( P_m = \frac{\mu}{\nu \nu_0} \) - Magnetic Prandtl number, \( f = \frac{m x}{\rho_0}, \quad E = \in \left[ 1 - (\epsilon) \xi_0 c_0 \right], \quad K_1 = \frac{\kappa}{\mu}, \quad E_r = E + h_T \in, \) and \( W = -q \epsilon \).

**5 Boundary conditions**

The boundary condition is

\[ W = \frac{d^2 W}{dz^2} = 0, \quad \theta = 0 \text{ at } z = 0 \text{ and } z = d. \quad (5.1) \]

**6 Dispersion Relation**

Taking curl on both side equation (4.8), we have

\[ \left[ \left\{ \frac{1}{\nu} \frac{\partial}{\partial t} + \frac{1}{K_1} \left( 1 + F \frac{\partial}{\partial t} \right) \right\} - \nabla^2 \right] L \frac{f}{\nu} \frac{\partial \tilde{q}}{\partial t} = L \left[ R \left( \frac{\partial \theta}{\partial y} \right) + \frac{\partial \theta}{\partial x} \right] \frac{2}{\nu} (\tilde{q} \times \Omega) + Q \frac{\partial}{\partial z} \left( \nabla \times \tilde{h} \right), \quad (6.1) \]

Let \( \nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}, \quad \nabla \tilde{h} = \frac{\partial^2}{\partial z^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial x^2}, \quad D = \frac{\partial}{\partial z}, \quad \xi = (\nabla \times \tilde{q}), \quad m_z = (\nabla \times \tilde{h}) \tilde{e}_z \text{ and } \tilde{h} \tilde{e}_z \text{ is the z-component of vorticity.} \]

Again, applying curl on both sides of equation (6.1) and (4.10), taking z-component on both side, we have

\[ \left[ \left\{ \frac{1}{\nu} \frac{\partial}{\partial t} + \frac{1}{K_1} \left( 1 + F \frac{\partial}{\partial t} \right) \right\} - \nabla^2 \right] \frac{f}{\nu} \frac{\partial \tilde{q}}{\partial t} = L \left[ R \nabla^2 \theta - \frac{2}{\nu} \Omega (D \xi) + QD \left( \nabla^2 \tilde{h} \right) \right], \quad (6.2) \]

\[ \in P_r \frac{\partial m_z}{\partial t} = D \xi + \in P_m \nabla^2 m_z, \quad (6.3) \]

Taking z-component on the both side of equation (6.1), (4.9) and (4.10), we have

\[ \left[ \left\{ \frac{1}{\nu} \frac{\partial}{\partial t} + \frac{1}{K_1} \left( 1 + F \frac{\partial}{\partial t} \right) \right\} - \nabla^2 \right] \frac{f}{\nu} \frac{\partial \tilde{q}}{\partial t} = L \left[ 2D \left( DW + QD m_z \right) \right], \quad (6.4) \]

\[ LP_r E_r \frac{\partial \theta}{\partial t} = L \left[ \nabla^2 \theta + W \right] + h_T W, \]

\[ \in P_r \frac{\partial \tilde{h}}{\partial t} = DW + \frac{P_m}{P_m} \nabla^2 \tilde{h}, \quad (6.5) \]
Now, the boundary condition (5.1) becomes

$$W = D^2W = Dm = h = \zeta = D\zeta = \theta atz = 0 \at z = 1$$  (6.7)

**Normal Mode Analysis**

Let

$$[W, m, \zeta, h, \theta] = [W(z), M(z), X(z), B(z), \Theta(z)]$$

Applying above normal mode of the equation (6.2) to (6.6), we have

$$\left[\frac{\sigma}{\epsilon} + \frac{1}{K_1} (1 + F\sigma) - (D^2 - a^2)\right] \left[(1 + \tau \sigma) + \frac{f}{\epsilon}\right] (D^2 - a^2) W = (1 + \tau \sigma) \left[-Ra^2\Theta - \frac{2}{\epsilon} \Omega DX + QD \left(D^2 - a^2\right) B\right],$$  (6.8)

$$\left[\frac{\sigma}{\epsilon} + \frac{1}{K_1} (1 + F\sigma) - (D^2 - a^2)\right] \left[(1 + \tau \sigma) + \frac{f}{\epsilon}\right] X = (1 + \tau \sigma) \left[\frac{2}{\epsilon} \Omega DW + QDM\right].$$  (6.9)

$$\left[\left\{E_r P_r \sigma - (D^2 - a^2)\right\} (1 + \tau \sigma)\right] \Theta = (1 + \tau \sigma) W + h_f W;$$  (6.10)

$$\left[\epsilon P_r \sigma - \frac{\epsilon P_r}{P_m} (D^2 - a^2)\right] M = DX;$$  (6.11)

$$\left[\epsilon P_r \sigma - \frac{\epsilon P_r}{P_m} (D^2 - a^2)\right] B = DW;$$  (6.12)

where $\sigma = \sigma_r + i\sigma_i$ is the stability parameter and $a^2 = k_x^2 + k_y^2$ is the wave number.

Now, the boundary condition becomes

$$W = D^2W = 0 = X = DX = G; \Theta = 0 \at z = 0 \to \zeta = 1,$$  (6.13)

$$D^\tau W = 0 \at z = 0 \to \zeta = 1, n > 0.$$

The proper solution of equation (6.13)

$$W = W_0 \sin \pi z \Rightarrow \text{Eliminating } \Theta, B \text{ and } X \text{ from equation (6.8) to (6.12), putting the value of } W \text{ and } b$$

$$= \pi^2 + a^2,$$  we have

$$b \left[\left\{\frac{\sigma}{\epsilon} + \frac{1}{K_1} (1 + F\sigma) + b\right\} (1 + \tau \sigma) + \frac{f}{\epsilon}\right] \left[(P_r E_r \sigma + b) (1 + \tau \sigma)\right] \left[P_r \sigma + \frac{P_r}{P_m} b\right]$$

$$\left[\left\{\frac{\sigma}{\epsilon} + \frac{1}{K_1} (1 + F\sigma) + b\right\} (1 + \tau \sigma) + \frac{f}{\epsilon}\right] \left\{\epsilon P_r \sigma + \frac{\epsilon P_r}{P_m} b\right\} + (1 + \tau \sigma) Q \pi^2$$

$$= Ra^2 (1 + \tau \sigma) \left\{1 + \tau \sigma + h_T\right\} \left\{P_r \sigma + \frac{P_r}{P_m} b\right\}$$

$$\left[\left\{\frac{\sigma}{\epsilon} + \frac{1}{K_1} (1 + F\sigma) + b\right\} (1 + \tau \sigma) + \frac{f}{\epsilon}\right] \left\{\epsilon P_r \sigma + \frac{\epsilon P_r}{P_m} b\right\} + (1 + \tau \sigma) Q \pi^2$$

$$- \frac{4 \Omega^2 \pi^2}{\epsilon} (1 + \tau \sigma) \left[P_r \sigma + \frac{P_r}{P_m} b\right]^2 \left[(P_r E_r \sigma + b) (1 + \tau \sigma)\right]$$

$$- \frac{Q b \pi^2}{\epsilon} (1 + \tau \sigma) \left[(P_r E_r \sigma + b) (1 + \tau \sigma)\right]$$

$$\left[\left\{\frac{\sigma}{\epsilon} + \frac{1}{K_1} (1 + F\sigma) + b\right\} (1 + \tau \sigma) + \frac{f}{\epsilon}\right] \left\{\epsilon P_r \sigma + \frac{\epsilon P_r}{P_m} b\right\} + (1 + \tau \sigma) Q \pi^2$$

(6.14)
7 Stationary Convection

Putting $\rho = 0$ in equation (6.15), we have

$$ R = \frac{1}{a^2 (1 + h_T)} \left[ b^2 \left( \frac{1}{K_1} + b \right) + \frac{Q \pi^2 b}{P_m} \frac{P_m}{P_r} + \frac{4 \Omega^2 \pi^2 b^2}{P_m} \frac{P_r}{P_m} \left\{ \left( \frac{1}{K_1} + b \right) \varepsilon P_r \frac{P_m}{P_m} + Q \pi^2 \right\} \right] $$

Neglecting the magnetic field, suspended particles and rotation, we have

$$ R = \frac{b^2}{a^2} \left( \frac{1}{K_1} + b \right) \quad (7.1) $$

Again, we take non-porous medium ($K_1 \to \infty$) then equation (7.2), reduce

$$ R = \frac{b^2}{a^2} $$

It is derived by G. Lebon and C. Perez-Garcia.

To discuss the behavior of medium permeability, magnetic field, suspended particles, rotation, and find the nature of $\frac{dR}{dK_1}$, $\frac{dR}{dQ}$, $\frac{dR}{dt}$ and $\frac{db}{d\Omega}$ respectively.

$$ \frac{dR}{dK_1} = -\frac{b^2}{a^2 K_1^2} \left( 1 + h_T \right) \left[ 1 - \frac{4 \Omega^2 \pi^2 b^2 (P_r/P_m)^2}{\left\{ \left( \frac{1}{K_1} + b \right) \varepsilon P_r \frac{P_m}{P_m} + Q \pi^2 \right\}^2} \right] $$

$$ \frac{dR}{dK_1} < 0 \text{ if } Q > \frac{2 \Omega \sqrt{b}}{\pi} \frac{P_r}{P_m}, \quad (7.2) $$

Now, ignoring the magnetic field, suspended particles and rotation, we have

$$ \frac{dR}{dK_1} = -\frac{b^2}{a^2 K_1^2} \quad (7.3) $$

Thus, the effect of medium permeability is destabilizing and is the same destabilizing effect when the magnetic field, suspended particles and rotation are neglected.

$$ \frac{dR}{dQ} = \frac{\pi^2 b \varepsilon P_r \frac{P_m}{P_r}}{a^2 (1 + h_T)} \left[ 1 - \frac{4 \Omega^2 \pi^2 b^2 (P_r/P_m)^2}{\left\{ \left( \frac{1}{K_1} + b \right) \varepsilon P_r \frac{P_m}{P_m} + Q \pi^2 \right\}^2} \right] $$

$$ \frac{dR}{dQ} > 0 \text{ if } \Omega < \frac{\varepsilon \sqrt{b}}{2 \pi}. \quad (7.4) $$

It is clear that the magnetic field has stabilizing effect.

$$ \frac{dR}{dh_T} = -\frac{b}{a^2 (1 + h_T)^2} \left[ b \left( \frac{1}{K_1} + b \right) + Q \pi^2 \frac{P_m}{P_r} \frac{P_m}{P_m} + \left\{ \left( \frac{1}{K_1} + b \right) \varepsilon P_r \frac{P_m}{P_m} + Q \pi^2 \right\} \right], \quad (7.5) $$

Thus, the suspended particles have destabilizing effect.

$$ \frac{dR}{d\Omega} = -\frac{1}{a^2 (1 + h_T)} \left[ \frac{8 \Omega^2 \pi^2 b^2}{P_m} \frac{P_r}{P_m} \frac{P_m}{P_m} \left\{ \left( \frac{1}{K_1} + b \right) \varepsilon P_r \frac{P_m}{P_m} + Q \pi^2 \right\} \right] $$

$$ \frac{dR}{d\Omega} < 0. \quad (7.6) $$

Now, we can say that the rotation has stabilizing effect.
8 Oscillatory Convection
Substituting $\sigma = i\omega$ in equation (6.14), we get real and imaginary parts, eliminating $R$ between them, we have $f_0\alpha_1 + f_1\alpha_2 + f_2\alpha_3 + f_3\alpha_4 + f_4\alpha_5 + f_5 = 0$.

Putting $s = \sigma^2$, we have

\[ f_0s^6 + f_1s^5 + f_2s^4 + f_3s^3 + f_4s^2 + f_5s + f_0 = 0. \quad (8.1) \]

where $f_0 = a_1q_1 - p_1b_1$, $f_1 = a_2q_1 + a_1q_2 - p_2b_1 - p_1b_2$, $f_2 = a_3q_1 + a_2q_2 + a_1q_3 - p_3b_1 - p_2b_2 - p_1b_3$, $f_3 = a_4q_1 + a_3q_2 + a_2q_3 - p_4b_1 - p_3b_2 - p_2b_3 - p_1b_4$, $f_4 = a_5q_1 + a_4q_2 + a_3q_3 - p_4b_2 - p_3b_3 - p_2b_4$, $f_5 = a_5q_2 + a_4q_3 - p_4b_3 - p_3b_4$, $f_6 = a_5q_3 - p_4b_4$.

\[ a_1 = b\tau \in E_rP_f^3 \left( \frac{\tau}{K_1} + \frac{F_r}{K_1} \right)^2, \quad b_1 = -a^2\tau^2 P_r \left\{ \frac{\tau}{K_1} + \frac{F_r}{K_1} \right\}, \]

\[ a_2 = -b\tau E_rP_f^2 \left[ \left( \frac{\tau}{K_1} + \frac{F_r}{K_1} \right) \left( \frac{1}{K_1} + b \right) + \frac{P_r}{F_m} \right], \]

\[ a_3 = b \left( br + F_r \right) \left( \frac{\tau}{K_1} + \frac{F_r}{K_1} \right)^2 + \frac{P_r}{F_m} \left\{ \frac{\tau}{K_1} + \frac{F_r}{K_1} \right\}, \]

\[ b_2 = a_2^2 \tau^2 P_r \left\{ \frac{\tau}{K_1} + b \right\} + \frac{P_r}{F_m} \left( br + F_r \right) \left( \frac{\tau}{K_1} + \frac{F_r}{K_1} \right)^2 + \frac{P_r}{F_m} \left\{ \frac{\tau}{K_1} + \frac{F_r}{K_1} \right\}, \]

\[ b_3 = -a^2 \left( 2\tau P_r + \tau^2 P_r \right) \left\{ \frac{\tau}{K_1} + b \right\} + \frac{P_r}{F_m} \left( br + F_r \right) \left( \frac{\tau}{K_1} + \frac{F_r}{K_1} \right)^2 + \frac{P_r}{F_m} \left\{ \frac{\tau}{K_1} + \frac{F_r}{K_1} \right\}, \]

\[ b_4 = -a^2 \left( 2\tau P_r + \tau^2 P_r \right) \left\{ \frac{\tau}{K_1} + b \right\} + \frac{P_r}{F_m} \left( br + F_r \right) \left( \frac{\tau}{K_1} + \frac{F_r}{K_1} \right)^2 + \frac{P_r}{F_m} \left\{ \frac{\tau}{K_1} + \frac{F_r}{K_1} \right\}, \]

\[ b_5 = a^2 \left( 2\tau P_r + \tau^2 P_r \right) \left\{ \frac{\tau}{K_1} + b \right\} + \frac{P_r}{F_m} \left( br + F_r \right) \left( \frac{\tau}{K_1} + \frac{F_r}{K_1} \right)^2 + \frac{P_r}{F_m} \left\{ \frac{\tau}{K_1} + \frac{F_r}{K_1} \right\}, \]

\[ b_6 = -a^2 \left( 2\tau P_r + \tau^2 P_r \right) \left\{ \frac{\tau}{K_1} + b \right\} + \frac{P_r}{F_m} \left( br + F_r \right) \left( \frac{\tau}{K_1} + \frac{F_r}{K_1} \right)^2 + \frac{P_r}{F_m} \left\{ \frac{\tau}{K_1} + \frac{F_r}{K_1} \right\}, \]

\[ b_7 = a^2 \left( 2\tau P_r + \tau^2 P_r \right) \left\{ \frac{\tau}{K_1} + b \right\} + \frac{P_r}{F_m} \left( br + F_r \right) \left( \frac{\tau}{K_1} + \frac{F_r}{K_1} \right)^2 + \frac{P_r}{F_m} \left\{ \frac{\tau}{K_1} + \frac{F_r}{K_1} \right\}, \]
From (8.1), we observed that \( s = \sigma_1^2 \) which is always positive, therefore the sum of roots equation of (8.1) is positive but this is impossible if \( f_0 > 0 \) and \( f_1 > 0 \), the sum of roots of equation (8.1) is \(-\frac{\beta}{\alpha_1}\). Thus, \( f_0 > 0 \) and \( f_1 > 0 \) are the sufficient condition for the non-existence of over stability.

Now \( f_0 > 0 \) and \( f_1 > 0 \) when \( Q > \frac{\varepsilon_2^3}{P_m} \) and \( b > \frac{1}{K_1} \). This condition for the non-existence of overstability.

9 Numerical Computation
In this section, we discussed the plotted variation of Rayleigh number \( R \) with \( K_1 \), \( Q \), \( h_T \) and \( \Omega \) from equation (7.1).
Figure 9.1, 9.2 and 9.3 shows the plots of Rayleigh number R versus medium permeability $K_1$ i.e. medium permeability increase then Rayleigh number decrease with magnetic field $Q = (100, 200, 300)$, wave number $a = (0.5, 1.0, 1.5)$ and suspended particles $h_T = (1, 2, 3)$ when $P_r = 2$, $\Omega = 10$, $\epsilon = 0.5$ and $P_r = 4$.

Now, neglecting the magnetic field, suspended particles and rotation in Figure 10.4, the Rayleigh number decrease when medium permeability increase. It is clear that, the effect of medium permeability is destabilizing. In the absence of magnetic field, suspended particles and rotation, the effect of medium permeability is always destabilizing.

Figure 9.5 and 9.6, represent the plot of Rayleigh number R versus magnetic field Q i.e. magnetic field increase then Rayleigh number increase with the wave number $a = (0.5, 1.0, 1.5)$ and suspended particles $h_T = (1, 2, 3)$ when $P_r = 2$, $\Omega = 10$, $\epsilon = 0.5$ and $P_r = 4$. Thus, we can say that the effect of magnetic field is stabilizing.

Figure 9.7 and 9.8, plot between Rayleigh number R and suspended particles $h_T$ i.e. suspended particles increase then Rayleigh number decrease with magnetic field $Q = (100, 200, 300)$ and wave number $a = (0.5, 1.0, 1.5)$ when $P_r = 2$, $\Omega = 10$, $\epsilon =$...
0.5sandP_r = 4. Hence, the effect of suspended particles destabilizing. Figure 9.9 and 9.10, shows the variation of Rayleigh number R versus rotation \( \Omega \) i.e. rotation increase then Rayleigh number increase with magnetic field.

\[ Q = (100, 200, 300), \text{ and suspended particles } h_f = (1, 2, 3) \text{ when } P_r = 2, \epsilon = 0.5sandP_r = 4. \]

10 Conclusions
According to numerically discussion and stationary convection, it was found that the effect of medium permeability and suspended particles are destabilizing. In the absence of magnetic field, suspended particles and rotation, the effect of medium permeability is always destabilizing. The effect of magnetic field and rotation are stabilizing. Among them the most important result that the effect of suspended particles destabilize on the system.

\[ Q > \frac{\epsilon b^2}{\pi^2 P_m} \text{ and } \frac{E_r P_r^2}{\epsilon^2} < \frac{1}{K_1}. \]

It is condition for the non-existence of over stability.

11 References
6. Kumar Vivek and Kumar Pardeep, Thermosolutal convection in a viscoelastic dusty fluid with hall currents in porous medium, Egyptian journal of basic and applied science, 2015; 3: 221-228.