Effect of the Couple-Stress on Micro Polar Rotating Fluid Flow Saturating a Porous Medium

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Abstract - Effect of the couple-stress on micro polar rotating fluid layer heated from below in the presence of varying gravitational field in a porous medium is studied, using normal mode, the problem has been analyzed and it is found that the permeability has destabilizing effect. The rotation, couple-stress parameter and micro-polar parameters have stabilizing effect. The condition of over stability has been found.
Keywords - Micro-Polar Fluid; Couple-Stress; Porous Medium; Rotation

1 Introduction

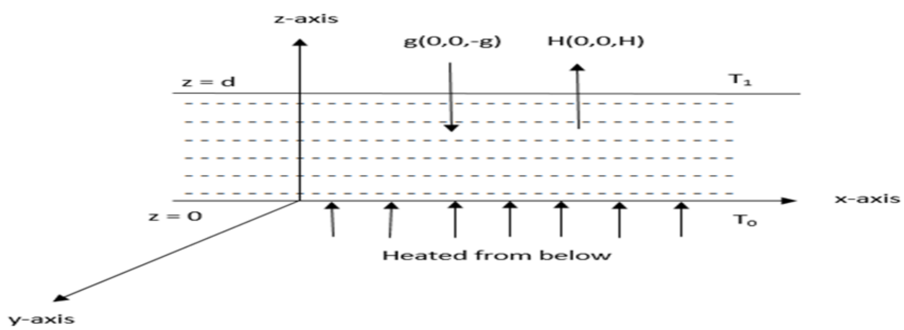
There are some important classes of fluid in technology areas, one of them being micro-polar fluid. The general theory of micro polar fluid was introduced Eringen[3] . Sharma and Gupta [8] investigated the thermal convection on micro polar fluid in porous medium. Sunil [12] et al. analyzed rotation and different parameters on a micro-polar ferromagnetic fluid flow. Mittal and Rana [5] investigated the medium permeability, suspended particles and other parameters on the micro-polar ferromagnetic fluid.
Stokes [11] study the classical concept of couple-stress fluid. Kumar Pardeep [4] et al. study the rotation on thermal instability in couple-stress viscous elastic fluid. Banyal and Singh [2] investigated the rotation on the couple-stress fluid in a porous medium. Shivakumara et al. [10] used the Galerkin method to investigate the convection in a couple-stress fluid flow. Pundir [6] et al. analyzed the effect of permeability, couple-stress parameter and magnetization. Shah Zahir et al. [7] discussed the effect of couple stress on micro polar fluid flow with hall current. Sharma K. Bhupendra et al. [9] study the effect of porosity, magnetic field and electrically conducting. Aparna P. et al. [1] investigated

the couple stress fluid on rotating permeable sphere. Xiong Pei-Ying et al. [13] analyzed the couple stress fluid flow between parallel plates with thermal convection.

Application of this work in geophysics, engineering science, chemical science and industry like as liquid crystal, blood flows, colloids suspensions and clean engine lubricants. In this paper, I attempt to study the couple-stress on micro-polar rotating fluid flow saturating a porous medium. To my knowledge this problem has not yet been investigated using the generalized Darcys model.

2 Mathematical Formulation

An infinite, horizontal, incompressible micro-polar fluid layer of thickness d is assumed and has porosity $\in$ and medium permeability k_1. The upper limit $z = d$ and lower limit $z = 0$ are maintained at constant but varying temperatures T_0 and T_1 such that a study adverse temperature gradient $\beta = \left|\frac{dT}{dz}\right|$ has been continued. The rotation and gravity are applied along z-axis to the system.



The equation of continuity, momentum, internal angular momentum, temperature and state is

$$\nabla.\vec{q} = o \tag{1}$$

$$\frac{\rho_0}{\in}\left[\frac{\partial \vec{q}}{\partial t} + \frac{1}{\in}\left(\vec{q}.\nabla\right)\vec{q}\right] = -\nabla P - \rho g \hat{e}_z + \left(\mu - \frac{\mu'}{\rho_0}\nabla^2\right)\nabla^2\vec{q} - \frac{1}{k_1}\left(\mu + \varsigma\right)\vec{q} + \varsigma\left(\nabla \times \vec{v}\right) + \frac{2\rho_0}{\in}\left(\vec{q} \times \Omega\right) \tag{2}$$

$$\rho_0 J\left[\frac{\partial \vec{v}}{\partial t} + \frac{1}{\in}\left(\vec{v}.\nabla\right)\vec{v}\right] = \left(\alpha' + \beta'\right)\nabla\left(\nabla.\vec{v}\right) + \gamma'\nabla^2\vec{v} + \frac{\varsigma}{\in}\left(\nabla \times \vec{q}\right) - 2\varsigma\vec{v} \tag{3}$$

$$\left[\in \rho_0 C_v + (1-\in)\rho_s C_s\right]\frac{\partial T}{\partial t} + \rho_0 C_v\left(\vec{q}.\nabla\right)T = \chi\,\nabla^2 T + \delta\left(\nabla \times \vec{v}\right).\nabla T \tag{4}$$

$$\rho = \rho_0\left[1 - \alpha\left(T - T_a\right)\right] \tag{5}$$

Where ρ - Fluid density, ρ_0 Reference density, $\vec{q}$ Filter velocity, $\vec{v}$ Spin (micro rotation), μ - Shear kinematic viscosity coefficient, ς - Coupling viscosity coefficient, P - Pressure, μ' - Couple stress viscosity, $\hat{e}_z$ - Unit vector in z-direction, α' - Bulk spin viscosity coefficient, β' - Shear spin viscosity coefficient, γ' - Micro-polar viscosity coefficient, J - Micro inertia constant, t - time, C_v - Specific heat at constant volume, C_s - Specific heat of solid (Porous Material Matrix), ρ_s - Density of solid matrix, χ - Thermal conductivity, T - Temperature, δ - Micro-polar heat conduction coefficient, α - Coefficient of thermal expansion.

3 Basic State of Problem

The basic state is

$$\vec{q} = \vec{q}_b\left(0,0,0\right), \; \vec{v} = \vec{v}_b\left(0,0,0\right), \; \rho = \rho = \rho_b\left(z\right) \; and \, P = P_b\left(z\right)$$

From equation (1) to (5)

$$\frac{dP_b}{dz} + \rho_b g = 0 \tag{6}$$

$$T = T_b\left(z\right) = -\beta z + T_a \tag{7}$$

$$\rho_b = \rho_0\left(1 + \alpha\beta z\right) \tag{8}$$

4 Linearize Perturbation Equations

$$\nabla.\vec{q}' = o \tag{9}$$

$$\frac{\rho_0}{\in}\frac{\partial \vec{q}'}{\partial t} = -\nabla P' + \alpha\theta g\hat{e}_z + \left(\mu - \frac{\mu'}{\rho_0}\nabla^2\right)\nabla^2\vec{q}' - \frac{1}{k_1}\left(\mu + \varsigma\right)\vec{q}' + \varsigma\left(\nabla \times \vec{v}'\right) + \frac{2\rho_0}{\in}\left(\vec{q}' \times \Omega\right) \tag{10}$$

$$\rho_0 J\frac{\partial \vec{v}'}{\partial t} = \left(\alpha' + \beta'\right)\nabla\left(\nabla.\vec{v}'\right) + \gamma'\nabla^2\vec{v}' + \frac{\varsigma}{\in}\left(\nabla \times \vec{q}'\right) - 2\varsigma\vec{v}' \tag{11}$$

$$E\frac{\partial \theta}{\partial t} + \left(\vec{q}.\nabla\right)T_b = k_T\nabla^2\theta - \frac{\delta}{\rho_0 C_v}\left(\nabla \times \vec{v}'\right)_z\beta + \beta(\vec{q}')_z \tag{12}$$

$$\rho' = -\rho_0\alpha\theta \tag{13}$$

Converting equation (9) to (13) by the following transform $x = dx*, y = dy*, z = dz*, \vec{q}' = \frac{k_T}{d}\vec{q}*, P' = \frac{\mu k_T}{d^2}P*, \vec{v}' = \frac{k_T}{d^2}\vec{v}*, t = \frac{\rho_0 d^2}{\mu}t*, \nabla = \frac{\nabla *}{d}, \theta = \beta d\,\theta*$, then we have

$$\nabla.\vec{q} = o \tag{14}$$

$$\frac{1}{\in}\frac{\partial \vec{q}}{\partial t} = -\nabla P + R\theta\hat{e}_z + \left(1 - F\nabla^2\right)\nabla^2\vec{q} - \frac{1}{K_1}\left(1 + K\right)\vec{q} + K\left(\nabla \times \vec{v}\right) + \frac{2}{\in}\left(\vec{q} \times \Omega\right) \tag{15}$$

$$\bar{J}\frac{\partial \vec{v}}{\partial t} = C_1\nabla\left(\nabla.\vec{v}\right) - C_0\nabla\left(\nabla \times \vec{v}\right) + K\left\{\frac{1}{\in}\left(\nabla \times \vec{q}\right) - 2\vec{v}\right\} \tag{16}$$

$$EP_r\frac{\partial\theta}{\partial t}=\nabla^2\theta-\bar{\delta}(\nabla\times\vec{v})_z+(\vec{q})_z \tag{17}$$

Where $R=\frac{\rho_0 g\alpha\beta d^4}{\mu k_T}$ - Thermal Rayleigh number, $P_r=\frac{\mu}{\rho_0 k_T}$ - Prandtl number, $F=\frac{\mu'}{\rho_0 d^2}$, $E=\in+\frac{(1-\in)\rho_s C_s}{\rho_0 C_v}$, $\bar{J}=\frac{J}{d^2}$, $K_1=\frac{k_1}{d^2}$, $\bar{\delta}=\frac{\delta}{\rho_0 C_v d^2}$, $C_0=\frac{\gamma'}{\mu d^2}$, $C_1=\frac{\alpha'+\beta'+\gamma'}{\mu d^2}$, and $W=\vec{q}.\hat{e}_z$.

5 Boundary conditions

$$W=\frac{d^2W}{dz^2}=0,\,\theta=0\,at\,z=0\,and\,z=d \tag{18}$$

6 Dispersion Relation

Taking curl on both side equation (15) then we have

$$\left[\frac{1}{\in}\frac{\partial}{\partial t}+\left(\frac{1+K}{K_1}\right)-\left(1-F\nabla^2\right)\nabla^2\right](\nabla\times\vec{q})=R\left(\frac{\partial\theta}{\partial x}\hat{e}_x+\frac{\partial\theta}{\partial x}\hat{e}_y\right)$$
$$+K\nabla\times(\nabla\times\vec{v})+\frac{2}{\in}\nabla\times(\vec{q}\times\Omega) \tag{19}$$

Let $\nabla^2=\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\frac{\partial^2}{\partial z^2}$, $\nabla_1^2=\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}$, $D=\frac{\partial}{\partial z}$, $\zeta_z=(\nabla\times\vec{q})_z$, ${\Omega_z}'=(\nabla\times\vec{v})_z$

Taking curl and z-component of equation (19), (16), then we have

$$\left[\frac{1}{\in}\frac{\partial}{\partial t}+\left(\frac{1+K}{K_1}\right)-\left(1-F\nabla^2\right)\nabla^2\right]\nabla^2W=R\nabla_1^2\theta+K\nabla^2\,{\Omega_z}'\,\hat{e}_z-\frac{2}{\in}\Omega\left(D\zeta_z\right) \tag{20}$$

$$\bar{J}\frac{\partial{\Omega_z}'}{\partial t}=C_0\nabla^2{\Omega_z}'-K\left[\frac{1}{\in}\nabla^2W+2{\Omega_z}'\right] \tag{21}$$

Taking z-component of equation (19) and (17) then we have

$$\left[\frac{1}{\in}\frac{\partial}{\partial t}+\left(\frac{1+K}{K_1}\right)-\left(1-F\nabla^2\right)\nabla^2\right]\zeta_z=\frac{2}{\in}\Omega DW \tag{22}$$

$$EP_r\frac{\partial\theta}{\partial t}=\nabla^2\theta-\bar{\delta}\,{\Omega_z}'+W \tag{23}$$

1. Normal Mode Analysis

Let $\left[W,\,\zeta_z,\,\theta,\,{\Omega_z}'\right]=\left[W\left(z\right),\,X\left(z\right),\,\Theta\left(z\right),\,G\left(z\right)\right]\,\exp.\left[i\,k_x x+i\,k_y y+\sigma t\right]$

Applying normal mode of equation (20) to (23), becomes

$$\left[\frac{\sigma}{\in}+\left(\frac{1+K}{K_1}\right)+F\left(D^2-a^2\right)^2-\left(D^2-a^2\right)\right]\left(D^2-a^2\right)W=-Ra^2\Theta$$
$$+K\left(D^2-a^2\right)G-\frac{2}{\in}\Omega DX \tag{24}$$

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$$\left[\frac{\sigma}{\in}+\left(\frac{1+K}{K_1}\right)+F\left(D^2-a^2\right)^2-\left(D^2-a^2\right)\right]X=\frac{2}{\in}\Omega DW \tag{25}$$

$$\left[m\sigma+2A-\left(D^2-a^2\right)\right]G=-\frac{A}{\in}\left(D^2-a^2\right)W \tag{26}$$

$$\left[EP_r\sigma-\left(D^2-a^2\right)\right]\Theta=-\bar{\delta}G+W \tag{27}$$

Where $a^2=k_x^2+k_y^2$ - wave number, $\sigma=\sigma_r+i\,\sigma_r$ - stability parameter and $m=\frac{\bar{J}A}{K}$, $A=\frac{K}{C_0}$, A - ratio between the micro-polar viscous effect and micro-polar diffusion effects.

$$W=D^2W=0=X=DX=G,\Theta=0\,at\,z=0\,to\,z=1 \tag{28}$$
$$D^{2n}W=0\,at\,z=0\,to\,z=1,\text{ Where } n>0.$$

The solution of equation (28) is

$$W=W_0\sin\pi z$$

Eliminating Θ, G, Φ, X from (24) to (27) and put the value of $W\ and\ b=\pi^2+a^2$, then we have

$$\begin{aligned}b\left[\frac{\sigma}{\in}+\left(\frac{1+K}{K_1}\right)+Fb^2+b\right]^2&[m\sigma+2A+b]\,[EP_r\sigma+b]\\ =Ra^2\left[\frac{\sigma}{\in}+\left(\frac{1+K}{K_1}\right)+Fb^2+b\right]&\left[(m\sigma+2A+b)-\frac{\bar{\delta}Ab}{\in}\right]\\ +\frac{KAb^2}{\in}&\left[\frac{\sigma}{\in}+\left(\frac{1+K}{K_1}\right)+Fb^2+b\right][EP_r\sigma+b]\\ &-\frac{4\Omega^2\pi^2}{\in^2}(m\sigma+2A+b)\,[EP_r\sigma+b]\end{aligned} \tag{29}$$

7 Stationary Convection

Put the $\rho=0$ in equation (29), then we have

$$R=\frac{1}{a^2\left[2A+b-\frac{\bar{\delta}Ab}{\in}\right]}\left[b^2(2A+b)\left(\frac{1+K}{K_1}+Fb^2+b\right)-\frac{KAb^3}{\in}+\frac{\frac{4\Omega^2\pi^2}{\in^2}b(2A+b)}{\left(\frac{1+K}{K_1}+Fb^2+b\right)}\right] \tag{30}$$

To study the behavior of permeability, rotation, couple-stress parameter coupling parameter, micro-polar coefficient, micro-polar heat transfer parameter and find the nature of $\frac{dR}{dK_1}$, $\frac{dR}{d\Omega}$, $\frac{dR}{dF}$, $\frac{dR}{dK}$, $\frac{dR}{dA}$ and $\frac{dR}{d\delta}$ respectively, then

$$\frac{dR}{dK_1}=\frac{-b(2A+b)(1+K)}{a^2{K_1}^2\left[2A+b-\frac{\bar{\delta}Ab}{\in}\right]}\left[b-\frac{\frac{4\Omega^2\pi^2}{\in^2}}{\left(\frac{1+K}{K_1}+Fb^2+b\right)}\right] \tag{31}$$

5

$$\frac{dR}{dK_1} < 0\, if\, \frac{4\Omega^2\pi^2}{b} < \in^2 \left(\frac{1+K}{K_1} + Fb^2 + b\right) and\, \bar{\delta} < \frac{\in}{A}$$

From equation (31), we can say that the permeability has destabilizing effect when $\frac{4\Omega^2\pi^2}{b} < \in^2 \left(\frac{1+K}{K_1} + Fb^2 + b\right) and\, \bar{\delta} < \frac{\in}{A}$.

$$\frac{dR}{d\Omega} = \frac{8\Omega\pi^2\in^{-2}b\,(2A+b)}{a^2\left(\frac{1+K}{K_1} + Fb^2 + b\right)\left[2A + b - \frac{\bar{\delta}Ab}{\in}\right]} \tag{32}$$

$$\frac{dR}{d\Omega} < 0\, if\ \bar{\delta} < \frac{\in}{A}$$

From equation (32) shows that the rotation has stabilizing effect when $\bar{\delta} < \frac{\in}{A}$.

$$\frac{dR}{dF} = \frac{b^3\,(2A+b)\left[b\left(\frac{1+K}{K_1} + Fb^2 + b\right)^2 - \frac{4\Omega^2\pi^2}{\in^2}\right]}{a^2\left(\frac{1+K}{K} + Fb^2 + b\right)^2\left[2A + b - \frac{\bar{\delta}Ab}{\in}\right]} \tag{33}$$

$$\frac{dR}{dF} > 0\, if\ \left(\frac{1+K}{K_1} + Fb^2 + b\right) > \frac{2\Omega\pi}{\in\sqrt{b}}$$

It is clear that the couple-stress parameter has stabilizing effect when $\left(\frac{1+K}{K_1} + Fb^2 + b\right) > \frac{2\Omega\pi}{\in\sqrt{b}}$.

$$\frac{dR}{dK} = \frac{b\left[Ab\left(\frac{2}{K_1} - \frac{b}{\in}\right)\left(\frac{1+K}{K_1} + Fb^2 + b\right)^2 + \left\{b^2\left(\frac{1+K}{K_1} + Fb^2 + b\right)^2 - \frac{4\Omega^2\pi^2(2A+b)}{\in^2}\right\}\frac{1}{K_1}\right]}{a^2\left(\frac{1+K}{K} + Fb^2 + b\right)^2\left[2A + b - \frac{\bar{\delta}Ab}{\in}\right]} \tag{34}$$

$$\frac{dR}{dK} > 0\, if\, \frac{2}{K_1} > \frac{b}{\in}\ and\ \left(\frac{1+K}{K_1} + Fb^2 + b\right) > \frac{2\Omega\pi\sqrt{(2A+b)}}{\in}$$

Hence the coupling parameter has stabilizing effect when $\frac{2}{K_1} > \frac{b}{\in}\ and\ \left(\frac{1+K}{K_1} + Fb^2 + b\right) > \frac{2\Omega\pi\sqrt{(2A+b)}}{\in}$.

$$\frac{dR}{dA} = \frac{\frac{b^4}{\in}\left(\frac{1+K}{K_1} + Fb^2 + b\right)^2\left[\bar{\delta} - K\left(\frac{1+K}{K_1} + Fb^2 + b\right)\right] + \frac{4\Omega^2\pi^2\bar{\delta}b^3}{\in^3}}{a^2\left(\frac{1+K}{K_1} + Fb^2 + b\right)\left[(2A+b) - \frac{\bar{\delta}Ab}{\in}\right]^2} \tag{35}$$

$$\frac{dR}{dA} > 0\ if\, \bar{\delta} > K\left(\frac{1+K}{K_1} + Fb^2 + b\right)$$

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From equation (35), we can say that the micro-polar coefficient has stabilizing effect when $\bar{\delta} > K\left(\frac{1+K}{K_1} + Fb^2 + b\right)$.

$$\frac{dR}{d\bar{\delta}} = \frac{\frac{Ab}{\in}}{a^2\left[(2A+b) - \frac{\bar{\delta}Ab}{\in}\right]^2}\left[b^3\left\{\left(\frac{1+K}{K_1} + Fb^2 + b\right) - \frac{KA}{\in}\right\}\right.$$
$$\left. + 2Ab^2\left(\frac{1+K}{K_1} + Fb^2 + b\right) + \frac{4\Omega^2\pi^2\in^{-2}b\,(2A+b)}{\left(\frac{1+K}{K_1} + Fb^2 + b\right)}\right] \quad (36)$$

$$\frac{dR}{d\bar{\delta}} > 0\,if\;\left(\frac{1+K}{K_1} + Fb^2 + b\right) > \frac{KA}{\in}$$

From equation (36), shows that the micro-polar heat transfer parameter has stabilizing effect when $\left(\frac{1+K}{K_1} + Fb^2 + b\right) > \frac{KA}{\in}$

8 Oscillatory Convection

Putting $\sigma = i\,\sigma_i$ in equation (29) then we get real and imaginary part, eliminating R between them, then we have

$$f_0\sigma_i^4 + f_1\sigma_i^2 + f_2 = 0$$

Put $s = \sigma_i^2$then we have

$$f_0 s^2 + f_1 s + f_2 = 0 \quad (37)$$

Where

$$f_0 = a_1 q_1 - p_1 b_1$$
$$f_1 = a_2 q_1 - p_2 b_1 - p_1 b_2$$
$$f_2 = a_3 q_1 - p_2 b_2$$
$$b_1 = -\frac{ma^2}{\in},\; a_1 = \frac{EP_r mb}{\in^2} \text{ and } b_2 = a^2\,(2A+b)\left\{\frac{1+K}{K_1} + Fb^2 + b\right\}$$

$$a_2 = -\left[\frac{\left\{(2A+b)\,b^2\right\}}{\in^2} + \frac{2b}{\in}\left(\frac{1+K}{K_1} + Fb^2 + b\right)\{(2A+b)\,EP_r + mb\}\right.$$
$$\left. + \left(\frac{1+K}{K_1} + Fb^2 + b\right)^2 EP_r mb\right] + \frac{KAb^2EP_r}{\in^2} - \frac{4\Omega^2\pi^2EP_r m}{\in^2}$$

$$a_3 = (2A+b)\,b^2\left(\frac{1+K}{K_1} + Fb^2 + b\right)^2 - \frac{KAb^3}{\in}\left(\frac{1+K}{K_1} + Fb^2 + b\right) + \frac{4\Omega^2\pi^2(2A+b)b}{\in^2}$$
$$P_1 = -\frac{1}{\in}\left[\frac{b}{\in}\{(2A+b)\,EP_r + mb\} + 2EP_r mb\left(\frac{1+K}{K_1} + Fb^2 + b\right)\right]$$

$$P_2 = \Big[2\left(2A+b\right) b^2 \in^{-1} \left(\frac{1+K}{K_1} + Fb^2 + b \right) + \left\{ \left(2A+b\right) EP_r + mb \right\} b \left(\frac{1+K}{K_1} + Fb^2 + b \right)^2 \Big] - \frac{KAb^2}{\in} \left(\frac{b}{\in} + EP_r \right) + \frac{4\Omega^2 \pi^2}{\in^2} \left[\left(2A+b\right) EP_r + mb \right]$$

$$q_1 = a^2 \left[\frac{(2A+b)}{\in} + m \left(\frac{1+K}{K_1} + Fb^2 + b \right) - \frac{\bar{\delta} Ab}{\in^2} \right]$$

From (37), we saying that $s = \sigma_i^2$ is positive, equation (37) for the sum of roots is positive, it is not possible if $f_0 > 0$ and $f_1 > 0$.
If $f_0 > 0$ and $f_1 > 0$ when $\bar{\delta} < \frac{\in}{A}$, $K < 4Fb \in$, $KEP_r < 4b \, and \, AKb^2 < 2\pi^2\Omega^2 m$.
Above conditions of the overstability.

9 Numerical Calculation

Now we show numerically effect of different parameter from equation (29)

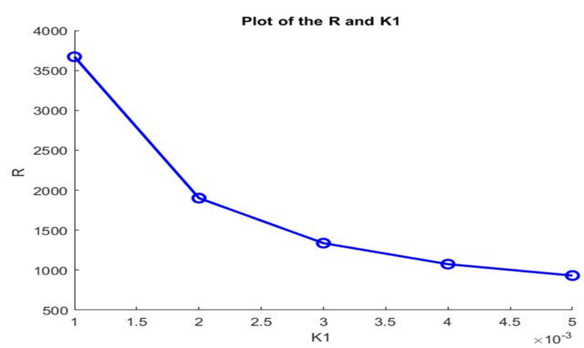

Figure 1:
$E = 1$, $\mathrm{P}_r = 2$, $\in = 0.5$, $A = 0.1$, $F = 2$, $K = 0.2$, $\Omega = 10 \, and \, \bar{\delta} = 0.05$.

Fig 1 shows the variation of Rayleigh number R with respect to medium permeability K_1 i.e. medium permeability K_1 increases then the Rayleigh number R decreases.

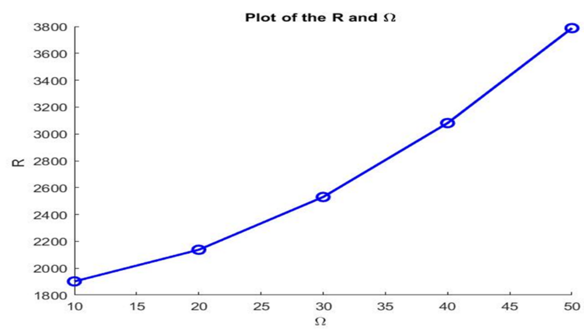

Figure 2:
$E = 1,\ \mathrm{P}_r = 2,\ \in= 0.5,\ A = 0.1,\ F = 2,\ K = 0.2,\ K_1 = 0.002\, and\, \bar{\delta} = 0.05.$

Fig 2 represent the plot of Rayleigh number R versus rotation ω i.e. rotation increases ω then the Rayleigh number R increases.

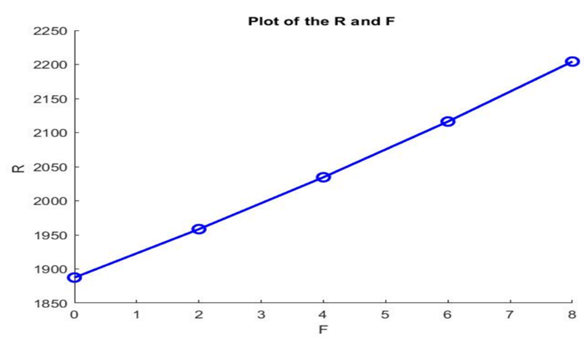

Figure 3:
$E = 1,\ \mathrm{P}_r = 2,\ \in= 0.5,\ A = 0.1,\ \Omega = 10,\ K = 0.2,\ K_1 = 0.002\, and\, \bar{\delta} = 0.05.$

Fig 3 plot between Rayleigh number R and couple-stress parameter F i.e. couple-stress parameter F increases then the Rayleigh number R increases.

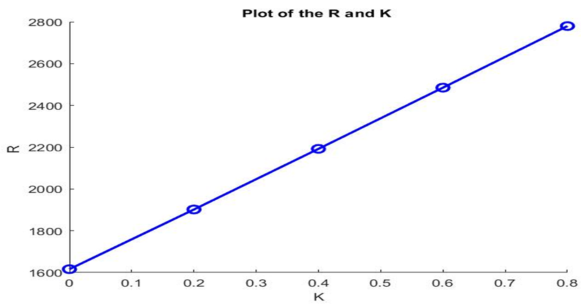

Figure 4:
$E = 1,\ \mathrm{P}_r = 2,\ \in = 0.5,\ A = 0.1,\ \Omega = 10,\ F = 2,\ K_1 = 0.002\, and\, \bar{\delta} = 0.05.$

Fig 4 shows the variation of Rayleigh number R with respect to coupling parameter K i.e. coupling parameter K increases then the Rayleigh number R increases.

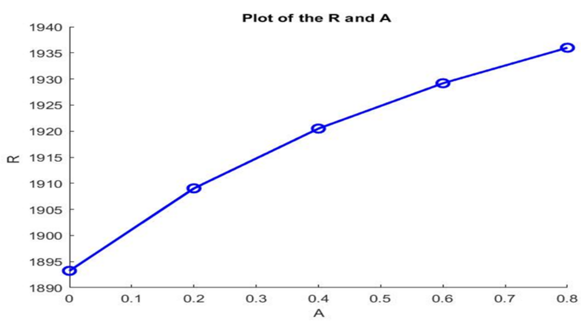

Figure 5:
$E = 1,\ \mathrm{P}_r = 2,\ \in = 0.5,\ K = 0.2,\ \Omega = 10,\ F = 2,\ K_1 = 0.002\, and\, \bar{\delta} = 0.05.$

Fig 5 represent the plot of Rayleigh number R versus micro-polar coefficient i.e. micro-polar coefficient A increases then the Rayleigh number R increases.

10 Conclusions

According to the stationary convection and numerically discussion we found that the effect of permeability is destabilizing. The effect of couple-stress parameter, rotation, coupling parameter, micro-polar coefficient and micro-polar heat conduction are stabilizing. Among them the most important result that the effect of rotation stabilize on the system. The condition of over stability is $\bar{\delta} < \frac{\in}{A}$, $K < 4Fb \in$, $KEP_r < 4b\, and\, AKb^2 < 2\pi^2\Omega^2 m.$

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