Abstract: The problem of triple diffusive surface tension driven convection is investigated in a composite layer in the presence of vertical magnetic field. A closed form solution is obtained under microgravity condition. The parameters suitable for fluid layer dominant and porous layer dominant composite layers are determined. The parameters appropriate for controlling the convection are determined which are useful to manufacture pure crystals.

Keywords: Triple diffusive, Species concentration, Magnetic field, Surface tension, Composite layer.

I. INTRODUCTION

The presence of more than one chemical dissolved in fluid mixtures is very often requested for describing natural phenomena such as contaminant transport, warming of stratosphere, magmas and sea water. The multi component has wide applications in crystal growth, geothermally heated lakes, earth core, solidification of molten alloys, underground water flow, acid rain effects and so on. For single fluid layer, Chand [1] has applied the linear stability analysis and a normal mode analysis to study the triple-diffusive convection in a micropolar ferromagnetic fluid layer heated and salted from below. Suresh Chand [10] has investigated the triple-diffusive convection in a micropolar ferrofluid layer heated and salted below subjected to a transverse uniform magnetic field in the presence of uniform vertical rotation. In porous medium, the triply diffusive convection in a Maxwell viscoelastic fluid is mathematically investigated in the presence of uniform vertical magnetic field through porous medium studied by Pawan Kumar Sharma et al. [8] using linearized stability theory and normal mode analysis.

For the composite layers, Sumithra [9] has studied the triple-diffusive Marangoni convection in a two layer system and obtained the analytical expression for the thermal Marangoni Number. Manjunatha and Sumithra [3-6] have investigated the combined effects of magnetic field and non uniform basic temperature gradients on two and three component convection in two layer system. In this paper the lower rigid surface of the porous layer and the upper free surface are considered to be insulating to temperature, insulating to both saline concentration perturbations. At the upper free surface, the surface tension effects depending on temperature and salinities are considered. At the interface, the normal and tangential components of velocity, heat and heat flux, mass and mass flux are assumed to be continuous and intended for Darcy-Brinkman model. The resulting eigenvalue problem is solved exactly and an analytical expression for the thermal Marangoni number is obtained for composite layer.

II. FORMULATION OF THE PROBLEM

Consider a three different diffusing components with different molecular diffusivities, electrically conducting fluid layer of thickness $d$ horizontal above the isotropic sparsely packed porous layer saturated with same fluid of thickness $d_p$ in the presence of magnetic field $H_0$ in the vertical $Z$-direction. The lower surface of the porous layer is considered to be rigid and the upper surface of the fluid layer is free at which the surface tension effects depending on temperature and both the species concentrations is considered. Both the boundaries are kept at different constant temperatures and salinities. A Cartesian coordinate system is chosen with the origin at the interface between porous and fluid layers and the $Z$-axis, vertically upwards.

The basic equations for fluid and porous layer respectively as,

\[ \nabla \cdot \vec{q} = 0 \]  
\[ \nabla \cdot \vec{H} = 0 \]  
\[ \rho_0 \left[ \frac{\partial \vec{q}}{\partial t} + (\vec{q} \cdot \nabla) \vec{q} \right] = -\nabla P + \mu \nabla^2 \vec{q} + \mu_p \left( \vec{H} \cdot \nabla \right) \vec{H} \]  
\[ \frac{\partial T}{\partial t} + (\vec{q} \cdot \nabla) T = \kappa \nabla^2 T \]
where

\[ T_{mb} = \frac{(T_{h} - T_{m}) z_m}{d_m} \quad 0 \leq z_m \leq d_m \]  
\[ C_{lb}(z) = C_{10} - \frac{(C_{10} - C_{lu}) z}{d_m} \quad 0 \leq z \leq d \]  
\[ C_{mb}(z) = C_{20} - \frac{(C_{20} - C_{mb}) z}{d_m} \quad 0 \leq z \leq d \]  
\[ C_{2mb}(z) = C_{20} - \frac{(C_{20} - C_{2mb}) z}{d_m} \quad 0 \leq z_m \leq d_m \] 

where

\[ T_{0} = \frac{\kappa d_1 T_{h} + \kappa d_2 T_{m}}{\kappa d_1 + \kappa d_2} \]  
\[ C_{10} = \frac{k_1 d_1 C_{1u} + k_1 d_2 C_{1b}}{k_1 d_1 + k_1 d_2} \]  
\[ C_{20} = \frac{k_2 d_1 C_{2u} + k_2 d_2 C_{2b}}{k_2 d_1 + k_2 d_2} \]

are the interface temperature and concentration and the subscript 'b' denotes the basic state.

To examine the stability of the system, we give a small perturbation to the system as

\[ \tilde{q} \]  
\[ \tilde{T} = \tilde{T}_{h} + \tilde{T}_{m} \]  
\[ \tilde{C} = C_{lb}(z) + \tilde{C}_{mb}(z) \]  
\[ \tilde{H} = H_{lb}(z) + \tilde{H}_{mb}(z) \]

Equations (23) & (24) are substituted into the (1) to (14), apply curl twice to eliminate the pressure term from (3) & (10) and then the variables are nondimensionalized.

To render the equations nondimensional, we choose different scales for the two layers (Chen and Chen [2], Nield [7]), so that both layers are of unit length such that

\[ (x, y, z) = d \left( x', y', z_m \right) \]  
\[ (x_m, y_m, z_m) = d_m \left( x_m', y_m', z_m - 1 \right) \]  

Omitting the primes for simplicity, we get in 0 \leq z \leq 1 and 0 \leq z_m \leq 1 respectively

\[ \frac{1}{Pr} \frac{\partial (\nabla^2 w)}{\partial t} = \nabla^4 w + Q_{m} \frac{\partial (\nabla^2 H)}{\partial z} \]

\[ \frac{\partial \theta}{\partial t} = W + \nabla^2 \theta \]  
\[ \frac{\partial S_{zb}}{\partial t} = W + \tau_{2} \nabla^2 S_{2} \]  
\[ \frac{\partial H_{zb}}{\partial t} = \frac{\partial W}{\partial t} + \tau_{2} \nabla^2 H_{2} \]
\[
\frac{\partial^2}{\partial t^2} \nabla^2 w_n = \mu \frac{\partial}{\partial z} \nabla^2 w_n - \nabla^2 w_n + Q_n \tau_{m1} \beta^2 \frac{\partial^2 H_{m1}}{\partial z^2} 
\]\n
(30)

\[
A \frac{\partial \theta_m}{\partial t} = w_n + \nabla^2 \theta_m 
\]

(31)

\[
e^{-S_{m1}(z)} = w_n + \tau_{m1} \nabla^2 s_{m1} 
\]

(32)

\[
e^{-S_{m2}(z)} = w_n + \tau_{m2} \nabla^2 s_{m2} 
\]

(33)

\[
\frac{\partial H_m}{\partial t} = \nabla^2 H_m + \tau_{m1} \nabla^2 H_m 
\]

(34)

Where, for the fluid layer Pr = \( \frac{V}{\kappa} \) is the Prandtl number, \( Q = \frac{\mu H \beta^2 d^2}{\mu k \tau_{m1}} \) is the Chandrasekhar number, \( \tau_{m1} = \frac{\kappa}{\kappa_{m1}} \) is the ratio salinity1 diffusivity to thermal diffusivity, \( \tau_{m2} = \frac{\kappa}{\kappa_{m2}} \) is the ratio salinity2 diffusivity to thermal diffusivity. For the porous layer, \( Pr_{m} = \frac{\alpha_{m}}{k} \) is the Prandtl number,

\[
\beta^2 = \frac{K}{d_m} = D_a \text{ is the Darcy number}, \quad \beta, \text{ porous parameter},
\]

\[
\dot{\mu} = \frac{H_m}{\mu} \text{ is the viscosity ratio}, \quad Q_m = \frac{\mu_{m} H_{m} \beta^2 d^2}{\mu_{m} \kappa_{m1} \tau_{m1}} = Q \epsilon d^2 \text{ is the Chandrasekhar number}.
\]

\( \tau_{m1} = \frac{\kappa_{m1}}{\kappa} \) is the ratio salinity1 diffusivity to thermal diffusivity, \( \tau_{m2} = \frac{\kappa_{m2}}{\kappa} \) is the ratio salinity2 diffusivity to thermal diffusivity, \( \theta \) and \( \theta_m \) are the temperature in fluid and porous layers respectively, \( S_1, S_2 \) and \( S_{m1}, S_{m2} \) are the concentrations in fluid and porous layer respectively and \( W \) and \( W_m \) are the dimensionless vertical velocities in fluid and porous layer respectively.

We apply normal mode expansion on dependent variables as follows,

\[
\begin{bmatrix}
w \\
\theta \\
S_1 \\
S_2 \\
H_m
\end{bmatrix} =
\begin{bmatrix}
W(z) \\
\Theta(z) \\
S_1(z) \\
S_2(z) \\
H(z)
\end{bmatrix} f(x, y) e^{i\alpha x y} 
\]

(35)

\[
\begin{bmatrix}
w_m \\
\theta_m \\
S_{m1} \\
S_{m2} \\
H_m
\end{bmatrix} =
\begin{bmatrix}
W_m(z_m) \\
\Theta_m(z_m) \\
S_{m1}(z_m) \\
S_{m2}(z_m) \\
H_m(z_m)
\end{bmatrix} f_m(x, y) e^{i\alpha_m x y} 
\]

(36)

With \( \nabla^2 f + a^2 f = 0 \) and \( \nabla^2 w_m + a^2 w_m = 0 \), where \( a \) and \( a_m \) are the nondimensional horizontal wavenumbers, \( n \) and \( n_m \) are the frequencies. Since the dimensional horizontal wavenumbers must be the same for the fluid and porous layers, we must have \( a = a_m \) and hence \( a_m = \frac{d}{d} \).

Introducing Eqs. (35) and (36) into the Eqs. (25) to (34) then we get an Eigen value problem consisting of the following ordinary differential equation in \( 0 \leq z \leq 1 \) and \( 0 \leq z_m \leq 1 \) respectively

\[
\left[D_m^{-2} - a_m^2 + \frac{n_m}{Pr_{m}} \nu \beta^2 \right] W_m = -Q \tau_{m1} D \left(D_m^{-2} - a^2 \right) H_m 
\]

(37)

\[
\left[D_m^{-2} - a_m^2 + n \nu \beta^2 \right] W_m = 0 
\]

(38)

\[
\left[D_m^{-2} - a_m^2 + n \nu \beta^2 \right] W_m + n \nu \beta^2 \left[D_m^{-2} - a_m^2 \right] H_m = 0 
\]

(39)

\[
\left[D_m^{-2} - a_m^2 + n \nu \beta^2 \right] W_m + n \nu \beta^2 \left[D_m^{-2} - a_m^2 \right] H_m = 0 
\]

(40)

\[
\left[D_m^{-2} - a_m^2 + n \nu \beta^2 \right] W_m = 0 
\]

(41)

\[
\left[D_m^{-2} - a_m^2 + n \nu \beta^2 \right] W_m + n \nu \beta^2 \left[D_m^{-2} - a_m^2 \right] H_m = 0 
\]

(42)

\[
\left[D_m^{-2} - a_m^2 + n \nu \beta^2 \right] W_m + n \nu \beta^2 \left[D_m^{-2} - a_m^2 \right] H_m = 0 
\]

(43)

\[
\left[D_m^{-2} - a_m^2 + n \nu \beta^2 \right] W_m + n \nu \beta^2 \left[D_m^{-2} - a_m^2 \right] H_m = 0 
\]

(44)

\[
\left[D_m^{-2} - a_m^2 + n \nu \beta^2 \right] W_m + n \nu \beta^2 \left[D_m^{-2} - a_m^2 \right] H_m = 0 
\]

(45)

\[
\left[D_m^{-2} - a_m^2 + n \nu \beta^2 \right] W_m + n \nu \beta^2 \left[D_m^{-2} - a_m^2 \right] H_m = 0 
\]

(46)

It is known that the principle of exchange of instabilities holds for triple diffusive magento convection in both fluid and porous layers separately for certain choice of parameters. Therefore, we assume that the principle of exchange of instabilities holds even for the composite layers. In other words, it is assumed that the onset of convection is in the form of steady convection and accordingly we take \( n_m = n_m = 0 \). Eliminating the magnetic field in Eqs. (41) and (46). The Eigen value problem becomes, in \( 0 \leq z \leq 1 \) and \( 0 \leq z_m \leq 1 \) respectively,

\[
\left[D^2 - a^2 \right] W = QD^2 W 
\]

(47)

\[
\left[D^2 - a^2 \right] \Theta + W = 0 
\]

(48)

\[
\tau_1 \left[D^2 - a^2 \right] S_1 + W = 0 
\]

(49)

\[
\tau_2 \left[D^2 - a^2 \right] S_2 + W = 0 
\]

(50)

\[
\left[D_m^{-2} - a_m^2 \right] \beta \mu \beta^2 - 1 \left[D_m^{-2} - a_m^2 \right] W_m = Q \tau_{m1} D^2 W_m 
\]

(51)

\[
\left[D_m^{-2} - a_m^2 \right] W_m + W_m = 0 
\]

(52)

\[
\tau_{m1} \left[D_m^{-2} - a_m^2 \right] S_{m1} + W_m = 0 
\]

(53)

\[
\tau_{m2} \left[D_m^{-2} - a_m^2 \right] S_{m2} + W_m = 0 
\]

(54)
III. BOUNDARY CONDITIONS

The boundary conditions are nondimensionalized then subjected to normal mode analysis and finally they take the form

\[ D^2 W(1) + a^2 M \Theta(1) + a^2 M_1 S(1) + a^2 M_2 S_2(1) = 0 \]
\[ W(1) = 0, D \Theta(1) = 0, D S_1(1) = 0, D S_1(1) = 0. \]

\[ \tilde{T} W(0) = W_m(0), \quad \tilde{T} \tilde{d} W(0) = D_m W_m(0), \]
\[ \tilde{d} \tilde{T} \left( D^2 + a^2 \right) W(0) = \tilde{\mu} (D_m^2 + a^2) W_m(0), \]
\[ \tilde{T} \tilde{d} \tilde{T} \left( D^2 + a^2 \right) W(0) - 3a^2 D^2 W(0) = -D_m W_m(1) + \tilde{\mu} \beta \left( D_m^2 W_m(1) - 3a^2 D_m W_m(1) \right). \]

\[ \Theta(0) = \tilde{T} \Theta_m(0), \quad D \Theta_m(0) = D_m \Theta_m(0), \]
\[ S_1(0) = \tilde{S}_1 S_m(1), \quad D S_1(0) = D_m S_1(0), \]
\[ S_2(0) = \tilde{S}_2 S_m(1), \quad D S_2(0) = D_m S_2(0), \]
\[ W_m(0) = 0, D_m W_m(0) = 0, D_m \Theta_m(0) = 0, \]
\[ D_m S_m(0) = 0, D_m S_m(0) = 0. \quad (55) \]

Where \( M = -\frac{\delta \sigma}{\tilde{T}} \frac{(T_0 - T_m)}{\mu \kappa} \) is the thermal Marangoni number, \( M_{s1} = -\frac{\delta \sigma}{\tilde{T}} \frac{(C_{10} - C_{1m})}{\mu \kappa} \) is the solute1 Marangoni number, \( M_{s2} = -\frac{\delta \sigma}{\tilde{T}} \frac{(C_{20} - C_{2m})}{\mu \kappa} \) is the solute2 Marangoni number, \( \tilde{T} = \frac{K_1}{K_m} \) is the ratio of thermal diffusivities of fluid to porous layer , \( \tilde{d} = \frac{d_m}{d} \) is the depth ratio, \( \tilde{S}_1 = \frac{K_1}{K_{1m}} \) is the ratio of solute1 diffusivities of fluid to porous layer, \( \tilde{S}_2 = \frac{K_2}{K_{2m}} \) is the ratio of solute2 diffusivities of fluid to porous layer.

IV. METHOD OF SOLUTION

From eqs (47) and (51), we get velocity distributions for fluid and porous layer respectively

\[ W(z) = A_1 \cosh \delta z + A_6 \sinh \delta z + A_4 \cosh \hat{z} z + A_6 \cosh \hat{z} z \]
\[ W_m(z_m) = A_1 \cosh c_1 z_m + A_2 \sinh c_1 z_m + A_3 \cosh c_2 z_m + A_4 \cosh c_2 z_m \]
\[ (56) \]

where

\[ W_m(z_m) \]
\[ (z_m) \]

where \( \delta = \frac{\sqrt{Q} + \sqrt{Q + 4a^2}}{2} \), \( \tilde{z} = \frac{\sqrt{Q} - \sqrt{Q + 4a^2}}{2} \) and \( A_i \)’s (\( i = 1, 2, \ldots, 8 \)) are arbitrary constants are obtained by using velocity boundary conditions of (55). The expressions for \( W(z) \) and \( W_m(z_m) \) are appropriately written as

\[ W_m(z_m) = A_1 [a_1 \cosh c_1 z_m + a_2 \sinhc c_1 z_m + a_3 \cosh c_2 z_m + a_4 \sinhc c_2 z_m] \]
\[ (57) \]

We get the species concentration for fluid layer \( S_1, S_2 \) from Eqs. (49) & (50) also from Eqs. (53) & (54), we get the species concentration for porous layer \( S_{m1}, S_{m2} \) using the species concentration boundary conditions of (55) as

\[ S_1(z) = A_1 [a_1 \cosh \delta z + a_2 \sinhc \delta z + \int \frac{f(z)}{r_1}] \]
\[ (58) \]

\[ S_1(z_m) = A_1 [a_1 \cosh c_1 z_m + a_2 \sinhc c_1 z_m + \int \frac{f(z)}{r_2}] \]
\[ (59) \]

\[ S_2(z) = A_1 [a_1 \cosh \delta z + a_2 \sinhc \delta z + \int \frac{f(z)}{r_1}] \]
\[ (60) \]

\[ S_2(z_m) = A_1 [a_1 \cosh c_1 z_m + a_2 \sinhc c_1 z_m + \int \frac{f(z)}{r_2}] \]
\[ (61) \]

\[ f(z) = (a_1 \sin \delta z + \cosh \delta z) \cdot (a_1 \sinh \delta z + a_2 \cosh \delta z) \]
\[ (62) \]

(63)
\[ \Delta_{410} = \frac{\Delta_{m}}{\Delta_{s10}} \left( a \Delta_{s10} - a \Delta_{s60} \right) - \Delta_{s10} \]

\[ \Delta_{410} = \frac{\Delta_{m}}{\Delta_{s10}} \left( a \Delta_{s10} - a \Delta_{s60} \right) - \Delta_{s10} \]

\[ \Delta_{m} = \frac{\Delta_{450}}{\Delta_{s10}} \left( a \Delta_{s10} - a \Delta_{s60} \right) - \Delta_{s10} \]

\[ \Delta_{s30} = a \sinh \alpha \Delta_{s30} + a \cosh \alpha \Delta_{s30} \]

**V. THERMAL MARANGONI NUMBER**

From eqs (48) & (52), we get temperature distributions for fluid and porous layers using temperature boundary conditions of (55) and they are

\[ \Theta(z) = A_0 \left( \alpha \cos h z + \alpha \sinh z - f(z) \right) \]

\[ \Theta_m (z_m) = A_0 \left( \alpha \cos h \delta z + \alpha \sinh \delta z - f_m (z_m) \right) \]

Where

\[ a_{i} = \frac{3}{2} \sinh \alpha \Delta_{i} + a \sinh \alpha \Delta_{i} - \Delta_{i} \]

\[ a_{i4} = \frac{4}{a} \left( a_{i4} \cos h \alpha \Delta_{i} + a_{i4} \sinh \alpha \Delta_{i} - \Delta_{i} \right) \]

\[ a_{i5} = \frac{4}{a} \left( a_{i5} \cos h \alpha \Delta_{i} + a_{i5} \sinh \alpha \Delta_{i} - \Delta_{i} \right) \]

\[ a_{i6} = \frac{4}{a} \left( a_{i6} \cos h \alpha \Delta_{i} + a_{i6} \sinh \alpha \Delta_{i} - \Delta_{i} \right) \]

\[ a_{i2} = \frac{4}{a} \left( a_{i2} \cos h \alpha \Delta_{i} + a_{i2} \sinh \alpha \Delta_{i} - \Delta_{i} \right) \]

\[ a_{i3} = \frac{4}{a} \left( a_{i3} \cos h \alpha \Delta_{i} + a_{i3} \sinh \alpha \Delta_{i} - \Delta_{i} \right) \]

The effects of the parameter \(a\) on thermal Marangoni number are depicted in figures 2 to 10.

\[ \Lambda_3 = M_{31} \frac{a^2}{a} \left[ \alpha \cos h a + \alpha \sinh a - \frac{R_s}{\tau_1} \right] \]

\[ \Lambda_4 = a^2 \left[ a \cos h a + a \sinh a - R_s \right] \]

\[ R_s = \left( a \sinh \delta + \cos h \delta \right) + \left( a \sinh \xi + a \cos h \xi \right) \]

\[ \left( \delta^2 - a^2 \right) + \left( \xi^2 - a^2 \right) \]

**VI. RESULT AND DISCUSSION**

The thermal Marangoni number \( M \) obtained as a function of the parameters is drawn versus the depth ratio \( \tilde{d} = \frac{d_s}{d} \) and the results are represented graphically showing the effects of the variation of one physical quantity fixing the other parameters. The dimensionless fixed values are

\[ \tilde{T} = 1.0, \ a = 1.2, \ \tilde{\mu} = 2.0, \ \beta = 0.3, \ \epsilon = 1.0, \ Q = 50, \ M_{11} = 10 \]

\[ M_{12} = 10, \ \tau_1 = \tau_2 = \tau_3 = \tau_4 = \tilde{S}_1 = \tilde{S}_2 = 0.75 \]

The effects of the parameters \(a, \beta, \epsilon, \tilde{\mu}, Q, \tau_1, M_{11}, M_{12}\) and \(\tau_{rel}\) on thermal Marangoni number are depicted in figures 2 to 10.

**Figure 2: Effects of horizontal wave number \(a\)**

Show the effects of \(a\), horizontal wave number on the thermal Marangoni number \( M \) for the values \( a = 1.3, 1.4, 1.5 \). It is evident from the graph that an increase in the value of \(a\), the thermal Marangoni number decreases and its effect is to destabilize the system. Also the curves are converging indicating that the effect of horizontal wave number is drastic for fluid layer dominant composite layers.
Figure 3 show the variations of the porous parameter \( \beta = \frac{K}{\sqrt{d_0}} \) on the thermal Marangoni number for the values \( \beta = 0.2, 0.3, 0.4 \). Increase in the value of \( \beta \), that is, increasing the permeability, the thermal Marangoni number increases. Hence the surface tension driven triple diffusive magneto convection sets in earlier on increasing the porous parameter, this may be due to presence of diffusing components. Also, for \( \hat{d} \geq 0.4 \) the thermal Marangoni number decreases to destabilize the system.

Figure 4 show the effects of porosity \( \varepsilon \) for the values \( \varepsilon = 0.8, 0.9, 1.0 \). It is observed that there is no effect of porosity for smaller value of depth ratio up to \( \hat{d} \geq 0.4 \). For \( \hat{d} \geq 0.4 \) the curves are diverging indicating that, its effect is drastic for larger depth ratios, hence its effect is immense for porous layer dominant composite layer. Whereas \( \varepsilon \) increases, the thermal Marangoni number decreases i.e., to destabilize the system.

Figure 5 show the variations of viscosity ratio \( \hat{\mu} \) for the values \( \hat{\mu} = 1.5, 2.0, 2.5 \). Increase in the value of \( \hat{\mu} \), the values of the thermal Marangoni number \( M \) increases for \( \hat{d} \leq 0.4 \). Also, \( \hat{d} \geq 0.4 \) the increase in the values of viscosity ratio decreases the thermal Marangoni number. By increasing the viscosity ratio the system can be stabilized or destabilized and hence the surface tension driven triple diffusive magneto convection is delayed or faster.

Figure 6 exhibits the effects of magnetic field on the onset of triple diffusive surface tension driven magneto convection by the Chandrasekhar number \( Q \) for the values \( Q = 50, 60, 70 \). When the value of the \( Q \) is increasing, the thermal Marangoni number increases for smaller depth ratio.
The curves are converging between the $0 \leq \hat{d} \leq 0.5$, which is evident that the effect of $Q$ is drastic for fluid layer dominant composite layer. Also, $\hat{d} \geq 0.5$ the curves are diverging indicating that the effect of $Q$ is effective for porous layer dominant composite layer.

Figure 7 display the effects of $\tau_1$, is the ratio of solute1 diffusivity to thermal diffusivity fluid in fluid layer for the values $\tau_1 = 0.50, 0.75, 1.0$. As increase in the value of $\tau_1$, there is a decrease in the values of the thermal Marangoni number. Increasing the value of $\tau_1$, the surface tension driven triple diffusive magneto convection sets in earlier i.e., system can be destabilized.

Figure 8 show the effects of $M_{s1}$ is the solute1 Marangoni number for $M_{s1} = 10, 20, 30$. By increasing the values of solute1 Marangoni number, the thermal Marangoni number increases. The surface tension driven triple diffusive magneto convection can be delayed by increasing solute1 Marangoni number, hence the system can be stabilized. Also the curves are converging which is evident that the effect of $M_{s1}$ is drastic for fluid layer dominant composite layer.

Figure 9 illustrates the effects of $M_{s2}$ is the solute2 Marangoni number for $M_{s2} = 100, 300, 500$. From the graph it is evident that, by increasing the values of solute2 Marangoni number the thermal Marangoni number decreases also for smaller depth ratio solute2 Marangoni number increases to stabilize the system. So, the surface tension driven triple diffusive magneto convection can be preponed by increasing solute2 Marangoni number, hence the system can be stabilized or destabilized. The converging curves indicating that $M_{s2}$ parameter is effective for the fluid layer dominant composite layer.

Figure 10 display the variations of the value of $\tau_{m1}$ is the ratio of salut1 diffusivity to thermal diffusivity of the porous layer for the values $\tau_{m1} = 0.50, 0.75, 1.0$. Increasing this ratio, thermal Marangoni number decreases. So, the surface tension driven triple diffusive magneto convection is preponed i.e., system can be destabilized. The converging curves indicating that $\tau_{m1}$ parameter is effective for the fluid layer dominant composite layer.
VII. CONCLUSION

(i) By decreasing horizontal wave number, porosity, ratio of solute1 diffusivity to thermal diffusivity fluid in fluid layer, solute2 Marangoni number, ratio of solute1 diffusivity to thermal diffusivity fluid in porous layer and by increasing the porous parameter, viscosity ratio, Chandrasekhar number, solute1 Marangoni number, the surface tension driven triple diffusive magneto convection can be delayed and hence the system can be stabilized.

(ii) The parameters $\beta, \varepsilon, \mu, Q, \tau_1$ and $M_{r,2}$ are effective for porous layer dominant composite layers.

(iii) The parameters $a, M_{s,1}$ and $\tau_{nl}$ are effective for fluid layer dominant composite layers.

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