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HEAT AND MASS TRANSFER EFFECTS ON THE FREE CONVECTION FLOW OF A VISCO-ELASTIC FLUID INSIDE A POROUS VERTICAL CHANNEL WITH SORET EFFECT

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Key words :

Free convection flow, Visco-elastic fluid, Heat and mass transfer, chemical reaction.

Abstract

Abstract: This paper deals with heat and mass transfer effects on the free convection flow of a visco-elastic fluid inside a porous vertical channel with Soret effect. Constitutive equations of continuity, motion, energy and concentration are formulated pertaining to the physical situations involved. Such equations are solved after being non-dimensionalised. Graphs and tables are drawn to study the effects of fluid parameters on the flow. It is observed that the non-Newtonian R_c accelerates the flow of the fluid upto certain distance from the lower plate of the channel(0.2<y<0.4). Similar effect is observed for the thermal Grashof number G_T.As source strength increases ,the temperature rises. But opposite effect is marked in case of the Reynolds number R. Species concentration decreases with the increase of the Schmidt number Sc.

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Mass transfer in all its remifications is an extremely large and complex subject. Many transport processes in occur nature in which the flow is caused by differences in concentration or material constitution. For example, the atmospheric flows at all scales are driven by both temperature and water concentration difference. The flows in water are caused by the effects of difference in temperature, concentration of dissolved substances and suspended particles of matter. Approximate solutions to many diverse applications as arise in Psychrometry, drying, evaporative cooling, transpiration cooling, diffusion controlled and ablation etc. have been developed theoretically by a number of researchers from time to time to explain such mass transfer cooling methods suggested by Hartnett and Eckert[1] are used to maintain the rate of heat transfer from hot fluid layers to solid surfaces at a minimum level.

The phenomenon of mass transfer is very common in the theories of stellar structure at least on the solar surface. Its origin is attributed to differences in temperature. Caused by the nonhomogeneous production of heat which in many cases can results not only in the formation of convective currents but also in violent explosions. Mass transfer certainly occurs within the months and cores of planets of the size of or larger than the Earth. Moreover, in many processes mass transfer and heat transfer occur simultaneously. In free convection, these may either hinder or aid one another. Analytical solutions to such problems have been presented by Sparrow and Cess[2], Sparrow, MinKowyoz and Eckert[3], Eichhorn[4], Gebhart and Pera[5] and a number of others. In all these works, the study of the mass transfer effects has been presented in case of semi infinite plates without considering the effects of suction on the free convective flow. But the study of mass transfer effects on the free convective flow in the presence of suction is more important from technological point of view, Gebhart[6] and also Gebhart and Mollendorf[7] have studied the mass transfer effects on the natural convective flow when the flow field is of extreme size or at extremely low temperature or in higy gravity field. Soundalgekar and Pop[8] has studied the mass transfer effects in case of an infinite vertical porous plate with suction. Also Ackerberg, Patel and Gupta[9] has studied experimentally the mass transfer effect on non-Newtonian fluid of Walters B' model. Dash and Biswal[10] have analysed the mass transfer effects of free convection flow of a visco-elastic fluid inside a porous vertical channel with heat sources.

The problem of the Heat and mass transfer of a non-Newtonian fluid flow over a permeable wedge in porous media with variable wall temperature and Concentration and heat source or sink has been studied by Chamkha[11]. Jena and Mathur[12] have discussed Free convection in the laminar boundary layer flow of a thermo-micropolar fluid past a vertical flat plate with suction/injection

In many engineering applications, combined effects of thermal diffusion and diffusion of chemical species are of importance. In some processes, the foreign gases are injected. This causes a reduction in wall shear stress, the mass transfer conductance of the rate of heat transfer. Sometimes, the evaporating material is coated on the surface of the body and this evaporates due to heating of the body and mixes with the flow of air past bodies. Such processes are the cases of steady free-convective flow with mass transfer. There are many other transfer processes in both industry and environment where both heat and mass transfer occur simultaneously. Such branches are ocean dynamics, Chemical engineering, aerospace engineering and pollution studies. Mass transfer effects in the absence of external magnetic field have been analysed by many researchers in case of both Viscous and visco-elastic fluids.

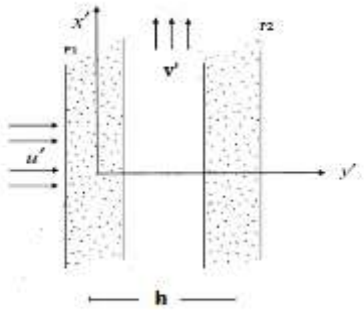
Bose and Basu[13] have analysed the MHD fluctuating flow of Non-Newtonian fluid through a porous medium bounded by an infinite porous plate. Non-Darcy effect on non-Newtonian Bingham fluid with heat transfer between two parallel plates has been investigated by Abbas,Attia and Abdeen[14]. Dhal, Jena and Sreekumar[15] have studied the MHD Convective heat and mass transfer flow past an inclined surface with heat generation and chemical reaction.

Chandrasekhar and Radha Narayan[16] have studied heat and mass transfer by natural convection near a vertical surface embedded in a variable porosity medium. Biswal and Mahalik[17] have analysed the unsteady free convection flow and heat transfer of a visco-elastic fluid past an impulsively started porous flat plate with heat sources or sinks. Paikray and Dash[18] have investigated the problem of heat and mass transfer in the unsteady Couette flow of Oldroyd liquid between two horizontal parallel porous plates with heat sources and chemical reaction when the lower plate moves with time varying velocity. Also, heat and mass transfer effects of free convection flow of visco-elastic fluid inside a porous vertical channel with constant suction and heat sources including chemical reaction have been by Paikaray and Dash[19]. To the best of our knowledge, very few efforts have been taken so far to study the effects of mass transfer on the flow of non-Newtonian fluids through porous medium with internal heat generating sources, constant suction, chemical reaction and soret effect.

In this problem our aim is to study the heat and mass transfer effect on the free convection flow of a visco-elastic fluid taking Walters 'B' model into account with heat sources, chemical reaction, constant suction and Soret effect, because both thermal diffusivity and molecular diffusivity influence the species concentration which also varies with chemical reaction. Velocity of the fluid is also modified by that.

2. MATHEMATICAL FORMULATION

We consider here a porous vertical channel having two plates P_1 and P_2 separated by a distance 'h'. The plates are infinitely stretched in the directions of X'-axis, so that at large distance from the entry, the flow is fully developed. The X'-axis is taken in the vertical direction and the Y'-axis is perpendicular to it. All the physical variables are therefore considered to be dependent of Y'-axis only. The positive direction is taken from P_1 to P_2.



[Fluid flow inside vertical channel]

Fig.0. Physical configuration of flow

Let u' and v' be the velocity of flow and suction velocity respectively. The derivations of the governing equations for the free convective flow with constant suction, heat sources and without the dissipative heat are presented following Walters 'B' liquid model in the presence of porosity of the medium, mass transport and Soret effect, which is caused due to thermal diffusivity.
In accordance with Walters 'B' liquid model given by

$$P_{ik}=pq_{ik}+p'_{ik}, \qquad (2.1)$$

Where

p_{ik} = stress tensor

p=an arbitrary isotropic Pressure,

$q_{ik(x)}$ = metric tensor of a fixed co − ordinate system x_j.

The constitutive equation of continuity, momentum, energy and concentration are as follows.

Equation of continuity:-

$$\frac{dv'}{dy'}=0 \qquad (2.2)$$

Which on integration gives

$$v' = \text{Constant} = -V_0 \qquad (2.3)$$

Hence, we take a constant suction velocity $-v_0$ normal to the plate. Obviously, the suction is towards the plate.

Equation of Motion:

$$\rho_0 v'\frac{du'}{dy'}=\eta_0\frac{d^2u'}{dy'^2}-k_0^* v'\frac{d^3u'}{dy'^3}+\rho_0 g\beta\left(T'-T_2'\right)$$

$$\rho_0 g\beta^*\left(C'-C_2'\right)-\frac{\eta_0}{K'}u' \qquad (2.4)$$

Equation of Energy:

$$v'\frac{dT'}{dy'}=\frac{k_0}{\rho_0 C_p}\frac{d^2T'}{dy'^2}+S'\left(T'-T_2'\right) \qquad (2.5)$$

Equation of concentration:

$$v'\frac{dC'}{dy'} = D\frac{d^2C'}{dy'^2} + \lambda' + D_1\frac{d^2T'}{dy^2} \qquad (2.6)$$

Where,

ρ_0 is the density of the fluid, g is the acceleration due to gravity,

β is the co-efficient of thermal expansion of the fluid,

η_0 is the co-efficient of viscosity of the fluid, $k^*{}_0$ is the dimensional elastic parameter,

C_p is the specific heat at constant pressure, k_0 is the thermal conductivity of the fluid,

S' is the source parameter, D is the chemical molecular diffusivity,

β^* is the volumetric co-efficient of expansion with concentration,

k' is the dimensional permeability parameter, D_1 is the thermal diffusivity co-efficient,

λ' is the reaction rate parameter and it is described by the power law model that takes the form

$$\lambda' = -k_1'(C' - C_2')^n$$

Where k_1' is the reaction rate constant and n is the order of the reaction as hold by Aris[30]

The boundary conditions of the problem are

$$\left.\begin{array}{l} y' = 0 : u' = 0, T' = T_1', C' = C_1' \\ y' = h : u' = 0, T' = T_2', C' = C_2', \end{array}\right\} \qquad (2.7)$$

On introducing the following non-dimensional parameters,

$$y = \frac{y'}{h}, u = \frac{u'h}{\upsilon}, T = \frac{T' - T_2'}{T_1' - T_2'}, C = \frac{C' - C_2'}{C_1' - C_2'},$$

$R = \dfrac{V_0 h}{\upsilon}$,the Reynolds number, $R_c = \dfrac{k_0^*}{\rho_0 h^2}$, the elastic parameter,

$G_T = \dfrac{g\beta h^3(T_1' - T_2')}{\upsilon^2}$, the Grashof number, $K = \dfrac{k_0}{\rho_0 C_p}$, the thermal diffusivity,

$G_c = \dfrac{g\beta^* h^3(C_1' - C_2')}{\upsilon^2}$, the modified Grashof number,

$K^* = \dfrac{k'}{h^2}$, non-dimensional permeability parameter,

$P = \dfrac{\eta_0 C_p}{k_0}$, the prandtl number, $S = \dfrac{4S'\upsilon}{V_0^2}$, the source parameter,

$S_c = \dfrac{\upsilon}{D}$, the Schmidt number, $K_1 = \dfrac{\upsilon k_1'}{V_0^2}$, the chemical reaction parameter

$S_1 = \dfrac{D_1(T_1' - T_2')}{\upsilon(C_1' - C_2')}$, the soret number

Where $\upsilon = \dfrac{\eta_0}{\rho_0}$, kinematic viscosity.

In equation (2.4) to (2.6) , we obtain

$$RR_c\frac{d^3u}{dy^3} + \frac{d^2u}{dy^2} + R\frac{du}{dy} - \frac{1}{K^*}u = -G_T T - G_C C, \qquad (2.8)$$

$$\frac{d^2T}{dy^2}+RP\frac{dT}{dy}+\frac{1}{4}R^2PST=0, \qquad (2.9)$$

$$\frac{d^2C}{dy^2}+RS_C\frac{dC}{dy}-R^2K_1S_CC+S_1S_C\frac{d^2T}{dy^2}=0, \quad (2.10)$$

and

with the modified boundary conditions,

$$\left.\begin{array}{l} y=0: u=0, T=C=1 \\ y=1: u=0, T=C=0, \end{array}\right\} \qquad (2.11)$$

3. SOLUTIONS OF THE EQUATIONS

Solving equation (2.9) , we obtain

$$T=A_1e^{-\alpha_1 y}+A_2e^{-\alpha_2 y}, \qquad (3.1)$$

Where,

Then solving the concentration equation (2.10) , we have

$$C=B_8e^{-\alpha_3 y}+B_9e^{-\alpha_4 y}+B_1e^{-\alpha_1 y}+B_2e^{-\alpha_2 y} \qquad (3.2)$$

Following Beard and Walters[21] the velocity equation(2.8) is solved by applying small parameter perturbation technique, taking R_c (<<1) as the perturbation parameter. Thus we obtain

$$\begin{aligned} u_0 &= G_T[A_9e^{-\alpha_5 y}+A_{10}e^{-\alpha_6 y}-A_5e^{-\alpha_1 y}-A_6e^{-\alpha_2 y}] \\ &+G_C[B_{22}e^{-\alpha_5 y}+B_{23}e^{-\alpha_6 y}-B_{12}e^{-\alpha_3 y}-B_{13}e^{-\alpha_4 y} \\ &-B_{14}e^{-\alpha_1 y}-B_{15}e^{-\alpha_2 y}] \end{aligned} \qquad (3.3)$$

$$\begin{aligned} u_1 &= G_T[A_{24}e^{-\alpha_7 y}+A_{25}e^{-\alpha_8 y}+A_{13}e^{-\alpha_5 y} \\ &+A_{14}e^{-\alpha_6 y}-A_{15}e^{-\alpha_1 y}-A_{16}e^{-\alpha_2 y}] \\ &+G_C[B_{39}e^{-\alpha_7 y}+B_{40}e^{-\alpha_8 y}-B_{24}e^{-\alpha_5 y} \\ &-B_{25}e^{-\alpha_6 y}-B_{26}e^{-\alpha_3 y}-B_{27}e^{-\alpha_4 y} \\ &-B_{28}e^{-\alpha_1 y}-B_{29}e^{-\alpha_2 y}] \end{aligned} \qquad (3.4)$$

Now , $u=u_0+R_cu_1$,

$$\begin{aligned} &G_T[A_{26}e^{-\alpha_7 y}+A_{27}e^{-\alpha_8 y}+A_{28}e^{-\alpha_5 y}+ \\ &A_{29}e^{-\alpha_6 y}-A_{30}e^{-\alpha_1 y}-A_{31}e^{-\alpha_2 y}] \\ &=+G_C[B_{41}e^{-\alpha_7 y}+B_{42}e^{-\alpha_8 y}+B_{43}e^{-\alpha_5 y} \\ &+B_{44}e^{-\alpha_6 y}-B_{45}e^{-\alpha_3 y}-B_{46}e^{-\alpha_4 y} \\ &-B_{47}e^{-\alpha_1 y}-B_{48}e^{-\alpha_2 y}] \end{aligned}$$

. (3.5)

Skin – Frictions:

There are two skin- frictions, one at the lower plate of the channel and other at the upper plate of the channel. Let τ_0 be the skin- friction at the lower plate of the channel and τ_1 at the upper plate of the channel. In general

$$\tau=\frac{du}{dy}\Big|_{y=0,1}+R_C\frac{d^2u}{dy^2}\Big|_{y=0,1} \qquad (3.6)$$

$$\tau_0 = \frac{du}{dy}|_{y=0} + R_C \frac{d^2u}{dy^2}|_{y=0} \qquad (3.7)$$

$$\tau_1 = \frac{du}{dy}|_{y=1} + R_C \frac{d^2u}{dy^2}|_{y=1} \qquad (3.8)$$

Substituting the value of u in the above equations, we have, neglecting the term containing $R_C^{\ 2}$, since R_C is very small,

$$\begin{aligned}\tau_0 &= G_T[X_1A_{26} + X_2A_{27} + X_3A_{28}\\ &+X_4A_{29} - X_5A_{30} - X_6A_{31}]\\ &+G_C[X_1B_{41} + X_2B_{42} + X_3B_{43} \qquad (3.9)\\ &+X_4B_{44} - X_7B_{45} - X_8B_{46}\\ &-X_5B_{47} - X_6B_{48}]\end{aligned}$$

Likewise

$$\begin{aligned}\tau_1 &= G_T[X_1A_{26}e^{-\alpha_7} + X_2A_{27}e^{-\alpha_8} + X_3A_{28}e^{-\alpha_5}\\ &+X_4A_{29}e^{-\alpha_6} - X_5A_{30}e^{-\alpha_1} - X_6A_{31}e^{-\alpha_2}]\\ &+G_C[X_1B_{41}e^{-\alpha_7} + X_2B_{42}e^{-\alpha_8} + X_3B_{43}e^{-\alpha_5} \qquad (3.10)\\ &+X_4B_{44}e^{-\alpha_6} - X_7B_{45}e^{-\alpha_3} - X_8B_{46}e^{-\alpha_4}\\ &-X_5B_{47}e^{-\alpha_1} - X_6B_{48}e^{-\alpha_2}]\end{aligned}$$

Rates of Heat transfer:

Generally, the rate of heat transfer is given by

$$Nu = -\frac{dT}{dy}, \qquad (3.11)$$

Where T is the temperature and Nu is the Nusselt number. At the lower plate, the rate of heat transfer is -given by

$$Nu_0 = -\frac{dT}{dy}|_{y=0} = [\alpha_1A_1 + \alpha_2A_2], \qquad (3.12)$$

Similarly, at the upper plate of the cannel, the rate of heat transfer is given by

$$Nu_1 = -\frac{dT}{dy}|_{y=1} = [\alpha_1A_1e^{-\alpha_1} + \alpha_2A_2e^{-\alpha_2}] \qquad (3.13)$$

Concentration Gradient:

In general, the concentration gradient is expressed as

$$CG = -\frac{dC}{dy}, \qquad (3.14)$$

Where C is the concentration of the species and CG is the concentration gradient.
At the lower plate of the channel, the concentration gradient is given by

$$CG_0 = -\frac{dC}{dy}|_{y=o} = [\alpha_3B_1 + \alpha_4B_2], \qquad (3.15)$$

At the upper plate of the channel, the concentration gradient is

$$CG_1 = -\frac{dC}{dy}\Big|_{y=1} = [\alpha_3 B_1 e^{-\alpha_3} + \alpha_4 B_2 e^{-\alpha_4}], \qquad (3.16)$$

4. RESULTS AND DISCUSSION

In our previous paper[14], we have investigated the problem of heat and mass transfer effects of free convection flow of visco-elastic fluid inside a porous vertical cannel with constant suction and heat sources including chemical reaction and without consideration of soret effect. Here, in the present study, we have extended the previous paper[14] with the effect of thermal diffusivity or Soret effect. So, heat transfer characteristics of the fluid are not affected only, the motion of the fluid and species concentration are modified. On the above ground, only velocity and concentration profiles are drawn to depict the flow behaviour and mass transfer characteristics.

Fluid Motion:

The characteristics of fluid flow are explored through the figures 1 and 2.

Fig .1 depicts the effect of elastic parameter R_c on the velocity of the fluid. It is observed that the velocity of the fluid is accelerated with the rise of non- Newtonian parameter R_C . The velocity of the fluid first rises, attains its peak value at a distance y=0.1 from the lower plate towards the upper plate of the channel. In case of Newtonian fluid (R_C =0.0), the velocity of the fluid approached zero towards the upper plate of the channel from the lower plate. The velocity of flow becomes negative after channel width h=0.4 and goes on decreasing upto h=0.5 and then rises and finally approaches to zero towards the upper plate of the channel, in case of R_C =0.05 . Similar case is marked for R_C=0.10 for visco-elastic flow of the fluid. In this case, the velocity of flow goes on attaining negative value after h=0.5 and then rises approaching zero value towards the upper plates of the channel.

The effect of the thermal Grashof number G_T on the flow profiles are presented by the Fig.2. In general the velocity of flow first rises, attains the peak value and then decreases attaining even negative values after the channel width h=0.35 and h=0.4 for G_T=5.0 and 10.0 respectively. Finally , after h=0.5 for G_T=5.0 and h=0.6 for G_T=10.0, the velocity rises approaching zero value towards the upper plate of the channel.

Concentration:

Profiles for species concentration are shown in fig.3 and 4 to explain the effects of Schmidt number S_C and Soret number S_1 on the concentration respectively. From fig.3, it is observed that the concentration falls with the rise of S_C .In general, the concentration decreases gradually with the distance from the lower plate to the upper plate of the channel while the reaction rate constant K_1 remains at zero value. Finally species concentration becomes zero at the upper plate of the channel, i.e at y=1.0, since the channel width varies from 0 to 1. When the reaction – rate constant K increases to 0.02 , keeping the Schmidt number S_C =2.7 fixed , then the concentration attains still lower value.

Fig .4 depicts the effect of the Soret number S_1 on the concentration of fluid. It is marked that the concentration decreased with the increase of the Soret number, which embodies the thermal diffusivity co-efficient D_1. Due to the action of thermal diffusion, the particles of the species become more mobile and which results in the fall of concentration. Higher value of Soret number means higher value of thermal diffusion co-efficient and hence rapid fall of species concentration. Generally concentration falls with the distance from the lower plate to the upper plate of the channel, i.e From y=0 to y=1.0.

Shear Stress:

Table 1

Effect of R_C ,G_T and S_C on the shear stresses at the lower plate and upper plate of the channel for R=10.0, P=1.3, S=0.1, G_C=0.0, K^*=0.1, K_1=0.02 and S_1=0.5

G_T	S_C	R_C	τ_1	τ_2
5.0	2.7	0.0	0.392237	-0.000058
		0.05	4.408769	0.001128
		0.10	8.425294	0.002314
	425	0.0	0.517603	-0.000202
		0.05	5.101030	0.002678
		0.10	9.684480	0.005559
10.0	2.7	0.0	0.789474	-0.000116
		0.05	8.817539	0.002256
		0.10	16.850589	0.004629
	425	0.0	1.035207	-0.000405
		0.05	10.202060	0.005356
		0.10	19.368961	0.011119

The values of shear stresses at the lower plate and at the upper plate are entered in the Table 1, where τ_1 the shear stress at the lower is plate and τ_2 is the shear stress at the upper plate of the channel. The effects of R_C , G_T and S_C on the shear stresses τ_1 and τ_2 are noticed from the numerical values of τ_1 and τ_2 entered in the above Table, keeping all other fluid parameters fixed. It is observed that the shear stresses τ_1 and τ_2 both increases with the rise of elastic parameter R_C . Similar effect is marked with the increase of Schmidt number S_C and thermal Grashof number G_T .

Table 2

Effect of heat source parameter S and Schmidt number S_C on the shear stresses τ_1 and τ_2 where p=1.3, G_T=5.0, G_C=0.00, R=10.0, R_C=0.05, K^*=0.1, K_1=0.02, S_1=0.5

S_C	S	τ_1	τ_2
2.7	0.1	4.408769	0.001128
	0.5	4.621935	0.001521
	1.0	5.503524	0.010835
425	0.1	4.408769	0.001128
	0.5	4.621935	0.001521
	1.0	5.101030	0.002678

Table 2 shows the effect of source parameter S on the skin–friction, when the values of other fluid parameters are kept fixed. It is observed that both the skin–frictions increase with the increase of source strength. Further it is worth mentioning here that the skin-frictions τ_1 and τ_2 decreases when source strength is high ie. S=1.0 and the Schmidt number also becomes high , i.e. From S_C=2.7 to S_C=425.

Rate of heat transfer:

Table 3

Effect of heat source parameter S and Reynolds number R on the rate of heat transfer for S_C=2.7, G_C=0.0, P=1.3, G_T=5.0, R_C=0.05

5.0	0.1	6.384638	0.010686
	0.5	5.452316	0.045306
	1.0	3.268923	0.120394
10.0	0.1	12.745042	0.000036
	0.05	11.599399	0.000093
	1.0	9.634639	0.000414

The rate of heat transfer is represented by the Nusselt number (Nu). The numerical values of the rate of heat transfer at the lower plate(Nu_1) and that at the upper plate (Nu_2) are entered in Table 3, with the variation of the Reynolds number (R) and the Source parameter (S) . It is observed that the rate of heat transfer at the lower plate of the channel decreases with the rise of source strength that changes from S=0.1 to S=1.0, keeping R constant. But the opposite effect is marked in case of the rate of heat transfer at the upper plate of the channel, ie. Nu_2 increases with the rise of the source strength S . But opposite effect is marked in case of the Reynolds number keeping source strength at constant value, ie. Nu_1 increases when R goes from 5 to 10 and at the same time Nu_2 decreases.

Concentration gradient:

Table 4

Effect of Schmidt number S_C and Soret number S_1 on the concentration gradients CG_1 and CG_2 for R=10.0, R_C=0.05, G_T=5.0, G_C=2.0, K^*=0.1, K_1=0.02, p=1.3 and S=0.5

S_C	S_1	CG_1	CG_2
2.7	0.5	27.01254	0.000589
	1.0	27.05629	0.002315
	1.5	27.08295	0.005206
425	0.5	1.00039	0.000093
	1.0	1.00205	0.000108
	1.5	1.00648	0.000719

Table 4 enumerates the effect of S_C and S_1 on the concentration gradient at the lower wall and upper wall of the channel. The numerical values of concentration gradient CG_1 at the lower wall and that CG_2 at the upper wall of the channel are entered in this table with the variation of the soret number S_1 and Schmidt number S_C . It is observed that both CG_1 and CG_2 increase with the increase of soret number S_1. But opposite effect is noticed in case of rise of S_C , ie. Both CG_1 and CG_2 falls when S_C increases from 2.7 to 425.

5. CONCLUSIONS

The present theoretical study of "heat and mass transfer effects on the free convection flow of a visco-elastic (Walters'B') fluid inside a porous vertical channel with constant suction, chemical reaction and Soret effect gives rise to the following remarkable findings.

(i) The velocity of the fluid is accelerated with the rise of non-Newtonian character of the fluid represented by R_C.

(ii) The velocity of the fluid first rises, attains its peak value and then decreases, finally becomes zero as the channel width increases from 0.0(lower wall) to 0.1(upper wall).

(iii) As the fluid is more and more non-Newtonian , the flow velocity becomes negative after certain distance from the lower wall of the channel towards the upper wall. For R_C =0.05, the flow velocity becomes negative at y=h=0.4 and for R_C =0.10, the flow reversal occurs at y=h=0.5.

(iv) The flow velocity rises with the rise of the thermal Grashof number G_T.

(v) The temperature of the fluid falls with the distance from the lower plate to the upper plate of the channel and which is invariably marked with the variations of the Reynolds number(R), prandtl number (P) and heat source parameter(S) , through the nature of fall varies from parameter to parameter. This result of ours regarding temperature has already been published in our previous paper[15].

(vi) The concentration falls with the rise of the Schmidt number S_C.

(vii) The concentration attains still lower value with the rise of reaction rate constant (K).

(viii) The concentration decreases with the increase of Soret number(S_1).

(ix) The shear stresses at the lower plate and upper plate of the channel rises wih the rise of elastic parameter R_C , Schmidt number S_C and the thermal Grashof number G_T .

(x) Both the skin –frictions τ_1 and τ_2 increase with the increase of the source strength (S).

(xi) For high Schmidt number and high Source strength , the shear stresses at the lower wall and upper wall of the channel decrease.

(xii) The rate of heat transfer Nu_1 at the lower wall of the channel decreases with the increase of source strength. But opposite effect is marked in case of the rate of heat transfer Nu_2 at the upper wall of the channel.

(xiii) Both the concentration gradients CG_1 and CG_2 at the lower wall and upper wall of the channel respectively increase with the increase of Soret number S_1. But opposite effect is marked in case of rise of the Schmidt number S_C.

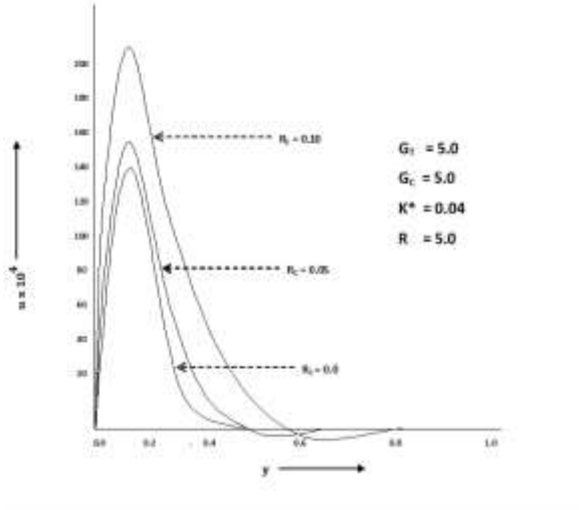


Fig.1 Effect of R_C on the velocity of the fluid

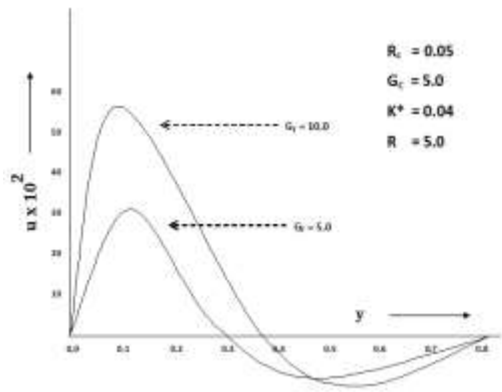


Fig.2 Effect of G_T on the velocity of the fluid

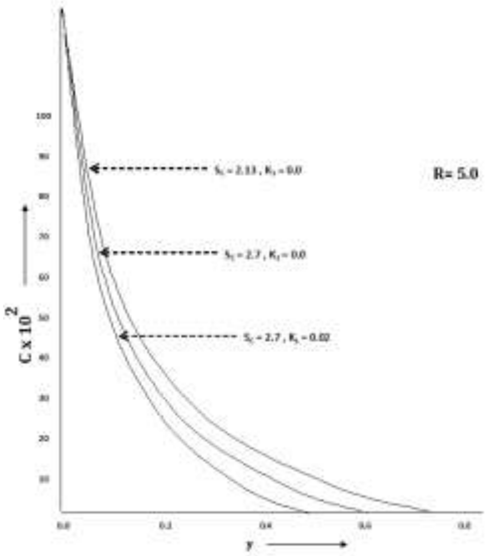


Fig.3 Effect of S_C, K_1 on Concentration of the fluid

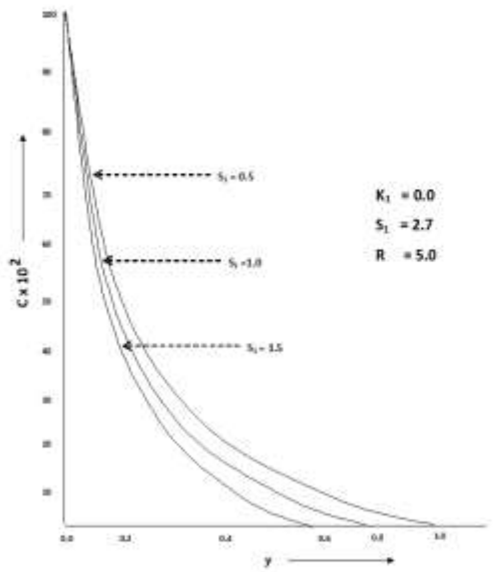


Fig.4 Effect of S_1 on Concentration of the fluid

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