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FEM ON HEAT AND MASS TRANSFER FLOW THROUGH POROUS MEDIUM IN A RECTANGULAR VESSEL WITH EFFECT OF THERMAL RADIATION AND DIFFUSION

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Abstract

The present article deal with deportation Calidity and conglomeration transposition flow over a permeable passable in a rectangular duct with effects of gratification effects , chemical reaction and radiation. With the help of finite element analysis(Galerkin method) with three nodded triangle elements we solved governing equations of flow heat and mass transfer. The ratio of momentum diffusivity P is taken to be 0.71. In this analysis we found the change in Sherwood number and Nusselt number (Nu) with respect to different parameters. In view of different parameters like Soret effect and radiation effect on non dimensional temperature, concentration has been discussed. This numerical results shown two different fluid flow systems related to the ratio of external Raleigh numbers together with the internal energy. Also, it was found that along the cold wall increased with higher external Rayleigh numbers and lowering with internal Rayleigh numbers. The Literature advocates that the variation of viscous dissipation with different geometries on heat transfer as been studied. By finite element analysis we analyses the mass and heat transfer in Porous Rectangular Cavity wit different parameters at side walls. Also we observed the thermal radiation acts convincing part in comprehensive surface fieriness displacement with lowering in heat transfer.

Keywords: *Mass and Heat transfer, Rectangular duct, Chemical reaction, radiation, dissipation*

NOMENCLATURE

$G = g\beta(T_h - T_c)a^3/\nu^2$ (Grashof number) C is Concentration, p′ pressure,

$P = \mu C_p / K_1$ (Prandtl number) T′ the temperature

$\alpha = Qa^z/K_1$ (Heat source parameter) g′ acceleration due to gravity,

$Ra = \beta g\left(T_g - T_c\right)Ka/\nu^2$ (Rayleigh Number) Cc is the cold side walls Concentration.

$N_1 = 3\beta_R K_1 / 4\sigma^{\bullet} T_e^3$ (Radiation parameter) T_c is the temperature on the cold side walls.

$Sc = \nu / D$ (Schmidt Number) T_h is temperature on the warm side walls

$So = k_{11}\beta^{\bullet} / \nu\beta$ (Soret parameter) $C_h$is warm side walls Concentration

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$N = \beta^*(C_h - C_c)/\beta(T_h - T_c)$ (Buoyancy ratio) μ is viscosity coefficient,

$Ec = a^4/\mu K K_1 \Delta T$ (Eckert number) ν is fluid kinematic viscosity

$M^2 = \sigma\mu_e^2 H_o^2 L^2/\nu$ (Hartmann Number) β is thermal expansion of fluid

$\gamma = \beta_1(T_H - T_C)/\beta_0$ (Density ratio) C_p is at constant pressure specific heat,

u′ , v′ are velocities in the direction of θ(x, y) Q is heat source strength,

k is porous medium permeability, ρ′ density,

k_{11} is the cross diffusivity, q_r is the radiative heat flux.

σis the conductivity of electricity, H_0 is strength of magnetic field

μ_e is the magnetic permeability of medium K_1 is the conductivity of thermal,

β* is mass fraction concentration with the expansion coefficient of volume

INTRODUCTION:

The great importance applications of natural convection are in many industrials. In view of preparing perfect crystals in modern electronics industry to produce transistors etc., Effects of natural convection enhances transport rate. The buoyancy-driven flows due to the mixture of gradients such as concentration temperature in the fluid studied by Viskanta*et. al.*,[23] and Ostrach [14].The pure gradients like temperature, concentration with in the cavities given in combined horizontal to study about rate of mass transfer and heat transfer analysedBejan [5].Variation of non dimensional temperature, concentration in horizontal enclosure of shallow in natural convective experimental deliberated Kamotani*et. al.*,[10]. Ostrach [14] and Lee [11] reports dealing with convection in rectangular enclosures with thermosolutal. The numerical solutions for rectangular enclosure with the help of effects due to heat and chemical concentration are coinside with the results of Hyun and Lee [9] reported. Double-diffusive in cavities with natural convection were considered by Ranganathan and Viskanta [17].

The natural currents and magnetic field can decrease the convection and crystal quality determined by Oreper and Szekely [13]. Maruo and Ozoe [15] found silicon-two dimensional due to natural convection gravitational force in numerical values of the rate of heat transfer. Alchaar[2] and Garandet [8] given in enclosed rectangular with convection natural heat transfer in a magnetic field of transverse. Al-Najem [3] and Rudraram [18] investigates the effects of heat, mass diffusion in the porous medium due the effects of free convection in magnetic field. The convection in two-dimensional square box with inclination and distributed uniformly using internal energy wellspring in an externally heated vertical investigated by Goldstein and Acharya [1]. The adiabatic rigid walls together with unsteady natural convection studied numerically with generating fluid heat and with isothermal rectangular cavity investigated by Churbanov*et. al.*,[7]. Chamkha [6] and Vajravelu and Nayfeh [21] accomplish oscillating fluid flow due to turbulence solutions and effects of dependent temperature with heat generation. The abnormality   of radiation, viscous dissipation on magneto hydrodynamic which is precarious with convection free flow through vertical plate in permeable medium premeditated by Verschoor*et. al.*, [22]. The heat transfer changes with respect to dissipation radiation on consecutive   in porous cavity scrutinized Badruddin[4]. Latterly Sreenivas [20], Nagaradhika [12] and Padmavathi [16] have kick around the conjunctional torriditydisplacement wound up a pervious ordinaryin a rectangular cariesplus torridnessorigination and divertissement under indiscriminate circumstances. Siva Nageswararao T [19]Displacement heat transfer along withcorpus transposeflow in a passage of rectangular transaction by bring to bear finite element resolution survey.

The overhead research, the adaptation of density is appropriated in the linear model

$$\Delta\rho = -\rho\beta\,(\Delta T) \qquad (1.1)$$

The converteddesignof (1.1) is applicative to water at 4^0c is disposed by

$$\Delta\rho = -\rho\gamma\,(\Delta T)^2 (1.2)$$

where$\gamma = 8 \times 10^{-6}\ (OC)^{-2}$. The non-linear density temperature change in free convection between vertical walls solved by Vajravelu, K and Nayfeh.J[21].

$$\Delta\rho = -\rho\beta g\,(T - T_e) - \rho\beta_1 (T - T_e)^2 \qquad (1.3)$$

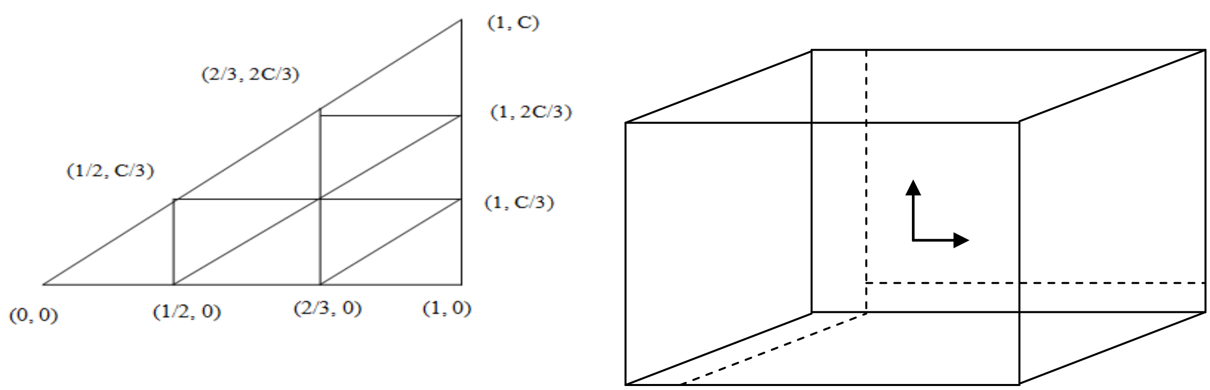

Fig.1. **REPRESENTATIONAL FIGURE OF FLOW MODEL**

2. FORMULATION OF THE PROBLEM

We acknowledgeblended assignment heat transfer, mass transmittal flow of a adhesive impenetrable fluid in a impregnatepermeable passable bedridden in the ovalfunnel (Fig. 1) whose offensiveportion(length) is a and prominence is (hight) b. hotness fluctuation on the offensive and vertex(top) walls is preservestabile. O (x, y) is selected with (0,0) as cartesian coordinate

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system on the dominant pivot of the funnel and draw foot likeness to $y=0$.

The authoritative equalizations disposed as

$$\frac{\partial u'}{\partial x'}+\frac{\partial v'}{\partial y'}=0 \tag{2.1}$$

$$u'=-\frac{k}{\mu}\left(\frac{\partial p'}{\partial x'}\right) \tag{2.2}$$

$$v'=-\frac{k}{\mu}\left(\frac{\partial p'}{\partial y'}+\rho' g\right)-\left(\frac{\sigma\mu_e^2H_o^2}{(\mu/\rho)}\right)v \tag{2.3}$$

$$\rho_\sigma c_p\left(u'\frac{\partial T'}{\partial x'}+v'\frac{\partial T'}{\partial y'}\right)=K_1\left(\frac{\partial^2 T'}{\partial x'^2}+\frac{\partial^2 T'}{\partial y'^2}\right)+Q(T_0-T)+\left(\frac{\mu}{K}\right)(u^2+v^2)-\frac{\partial(q_r)}{\partial x} \tag{2.4}$$

$$\rho_\sigma c_p\left(u'\frac{\partial C}{\partial x'}+v'\frac{\partial C}{\partial y'}\right)=D_1\left(\frac{\partial^2 C}{\partial x'^2}+\frac{\partial^2 C}{\partial y'^2}\right)+k_{11}\left(\left(\frac{\partial^2 T}{\partial x'^2}+\frac{\partial^2 T}{\partial y'^2}\right)\right. \tag{2.5}$$

$$\rho'=\rho_0\left\{1-\beta_0(T'-T_0)-\beta_1(T'-T_0)^2-\beta^\bullet(C'-C_0)\right\}$$
(2.6)

$$T_0=\frac{T_h+T_c}{2},C_0=\frac{C_h+C_c}{2}$$

The extremitysurroundings are

$u'=v'=0$ on the vessel extremity

$T'=T_c$, $C=C_c$ at the left fence bank border

$T'=T_h$, $C=C_h$ on the right wall division (2. 7)

$\frac{\partial T'}{\partial y}=0$, $\frac{\partial C}{\partial y}=0$ at vertex (x-axis) &basement $v=0$ & $u=0$ banks ($y=0$) whatever seclude.

Importune Rosselandalikeness whereas diffusion

$$q_r=\frac{4\sigma^*}{3\beta_R}\frac{\partial T'^4}{\partial y}$$

Inflate T^4 in expansion of the series Taylor's about T_e&overlooking greater power terms

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$$T'^4 \cong 4T_e^3 T - 3T_e^4$$

Announce the consecutive non-geometric warble

$$x' = ax;\ \ y' = by;\ \ c = {}^{b}\!/_{a}$$

$$u' = \left({}^{\nu}\!/_{a}\right)u;\ \ v' = \left({}^{\nu}\!/_{a}\right)v;\ \ p' = \left({}^{\nu^2\rho}\!/_{a^2}\right)p$$

$$T' = T_0 + \theta\left(T_h - T_c\right);\ C' = C_0 + \phi\left(C_h - C_c\right) \tag{2.8}$$

The supreme comparison in the non- structural profiles as

$$u = -\left(\frac{K}{a^2}\right)\frac{\partial p}{\partial x} \tag{2.9}$$

$$v = -\frac{k}{a^2}\frac{\partial p}{\partial y} - \frac{kag}{\nu^2} + \frac{kag(\beta_0(T_h - T_c)\theta}{\nu^2} + \frac{\beta_1(T_h - T_c)^2\theta^2)}{\nu^2} + \frac{kag\beta^{\bullet}(C_h - C_c)\phi}{\nu^2} - (\frac{\sigma\mu_e^2 H_o^2}{(\mu/\rho)})v \tag{2.10}$$

$$P\left(u\frac{\partial\theta}{\partial x} + v\frac{\partial\theta}{\partial y}\right) = \left(1 + \frac{4N}{3}\right)\left(\frac{\partial^2\theta}{\partial x^2} + \frac{\partial^2\theta}{\partial y^2}\right) - \alpha\theta + E_C\left(u^2 + v^2\right) \tag{2.11}$$

$$Sc\left(u\frac{\partial\phi}{\partial x} + v\frac{\partial\phi}{\partial y}\right) = \left(\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2}\right) + \frac{ScSo}{N}\left(\frac{\partial^2\theta}{\partial x^2} + \frac{\partial^2\theta}{\partial y^2}\right) \tag{2.12}$$

In view of (1.1) we announce the stream function ψ as

$$u = \frac{\partial\psi}{\partial y}\ \ ;\ \ \ \ v = -\frac{\partial\psi}{\partial x} \tag{2.13}$$

Do away with p in (2.9) & (2.10) and avail oneself of (2.11) the relations in ψ and θ are

$$((1 + M^2)\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2}) = -Ra(\frac{\partial\theta}{\partial x}) - Ra(\frac{\partial\theta}{\partial x} + 2\gamma\theta\frac{\partial\theta}{\partial x} + N\frac{\partial\phi}{\partial x}) \tag{2.14}$$

$$P\left(\frac{\partial\psi}{\partial y}\ \frac{\partial\theta}{\partial x}\ - \frac{\partial\psi}{\partial x}\ \frac{\partial\theta}{\partial y}\right) = \left(1 + \frac{4}{3N_1}\right)\left(\frac{\partial^2\theta}{\partial x^2} + \frac{\partial^2\theta}{\partial y^2}\right) - \alpha\theta + E_C\left(\left(\frac{\partial\psi}{\partial y}\right)^2 + \left(\frac{\partial\psi}{\partial x}\right)^2\right) \tag{2.15}$$

$$Sc\left(\frac{\partial\psi}{\partial y}\ \frac{\partial\phi}{\partial x}\ - \frac{\partial\psi}{\partial x}\ \frac{\partial\phi}{\partial y}\right) = \left(\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2}\right) + \frac{ScSo}{N}\left(\frac{\partial^2\theta}{\partial x^2} + \frac{\partial^2\theta}{\partial y^2}\right) \tag{2.16}$$

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where theterminalcircumstances are

$$\frac{\partial \psi}{\partial x} = 0, \frac{\partial \psi}{\partial y} = 0 \ on \quad x = 0 \ \& 1 \qquad (2.17)$$

$$\theta = 1 \quad \phi = 1 \quad on \quad x = 0$$

$$\theta = 0 \quad \phi = 0 \quad on \quad x = 1 \qquad (2.18)$$

3. FEM Technique

By partite the region into a definite ordinal of 3 knob three-sided component, in each of which

the equations associated with the elements is imitative using Galerkin FEM method weighted continuing approach. f_i is an element in the relative result for an anonymous f in the changes regulation is pronounce as a linear consolidation of likeness relation $\left(N_k^i\right)$, where $k = 1, 2, 3$. The linear polynomials in variables y & x. The comparative elucidation of the f_i which is unknown synchronizes with real values at all vertex's of the particle. The changes of configuration conclusions in a matrix of order 3 x 3 (firmness matrix) relation for anonymous provincial nodal numerical at given point. The rigidity matrix's are massed in reservation of comprehensive using with border and interior element prolongation circumstances appears in global matrix equation which contains nodal values

For different cases the global nodes are r which are distinct in FED and the comprehensive nodal values f_p (p = 1, 2, ……, r) of any nameless f characterize over the scope then

$$f = \sum_{i=1}^{8} \sum_{p=1}^{r} f_p \ \Phi_p^i ,$$

here 1st aggregate indicates sum over the number of elements "s" and the 2nd indicates sum done with the autonomous universal nodes and

$\Phi_p^i = N_N^i$, if p is one of the provincial bulge say k of the element e_i,

= 0, or else.

f_p's unflinching from the universal matrix equations. Placed on these lineswe make a FEA on disposed lines placed in the problem directed by (2.14) to (2.16) command effects the circumstances (2.17) & (2.18).

Let ϕ^i,ψ^i and θ^i be the comparative values of ϕ, θ and ψ in an element of the form θ_i.

$$\psi^i = N_1^i \ \psi_1^i + N_2^i \ \psi_2^i + N_3^i \ \psi_3^i \qquad (3.1a)$$

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$$\theta^i = N_1^i\ \theta_1^i + N_2^i\ \theta_2^i + N_3^i\ \theta_3^i \tag{3.1b}$$

$$\phi^i = N_1^i\ \phi_1^i + N_2^i\ \phi_2^i + N_3^i\ \phi_3^i \tag{3.1c}$$

Supposititious the comparative appraisal θ^i ,ϕ^i and ψ^i , for θ, ϕ and ψall at once in (2.13), the blunder

$$E_1^i = \left(1+\frac{4}{3N_1}\right)\frac{\partial^2\theta^i}{\partial x^2}+\frac{\partial^2\theta^i}{\partial y^2}-P\left(\frac{\partial\psi^i}{\partial y}\ \frac{\partial\theta^i}{\partial x}\ -\frac{\partial\psi^i}{\partial x}\ \frac{\partial\theta^i}{\partial y}\right)-\alpha\theta+E_C\left[\left(\frac{\partial\psi}{\partial y}\right)^2+\left(\frac{\partial\psi}{\partial x}\right)^2\right] \tag{3.2}$$

$$E_2^i = \frac{\partial^2\phi^i}{\partial x^2}+\frac{\partial^2\phi^i}{\partial y^2}-Sc\left(\frac{\partial\psi^i}{\partial y}\ \frac{\partial\phi^i}{\partial x}\ -\frac{\partial\psi^i}{\partial x}\ \frac{\partial\phi^i}{\partial y}\right)+\frac{ScSo}{N}\left(\frac{\partial^2\phi^i}{\partial x^2}+\frac{\partial^2\phi^i}{\partial y^2}\right) \tag{3.3}$$

Beneath Galerkin approach this misconception is manufactured quadrate finished the occupation of e_i to the relevant outline objective (weight purpose) here

$$\int_{ei} E_1^i\ N_k^i\ d\Omega = 0$$
,
$$\int_{ei} E_2^i N_k^i d\Omega = 0$$

$$\int_{ei} N_k^i\left(\left(1+\frac{4}{3N_1}\right)\left(\frac{\partial^2\theta^i}{\partial x^2}+\frac{\partial^2\theta^i}{\partial y^2}\right)-P\left(\frac{\partial\psi^i}{\partial y}\ \frac{\partial\theta^i}{\partial x}\ -\frac{\partial\psi^i}{\partial x}\ \frac{\partial\theta^i}{\partial y}\right)-\alpha\theta+\left[E_C\left(\frac{\partial\psi}{\partial y}\right)^2+\left(\frac{\partial\psi}{\partial x}\right)^2\right]\right)d\Omega = 0$$

(3.4)

$$\int_{ei} N_k^i\left(\left(\frac{\partial^2\phi^i}{\partial x^2}+\frac{\partial^2\phi^i}{\partial y^2}\right)-Sc\left(\frac{\partial\psi^i}{\partial y}\ \frac{\partial\phi^i}{\partial x}\ -\frac{\partial\psi^i}{\partial x}\ \frac{\partial\phi^i}{\partial y}\right)+\frac{ScSo}{N}\left(\frac{\partial^2\theta^i}{\partial x^2}+\frac{\partial^2\theta^i}{\partial y^2}\right)\right)d\Omega = 0 \tag{3.5}$$

employing Green's theorem principle (3.5) truncate into

$$\int_\Omega \begin{pmatrix} (1+M^2)\dfrac{\partial N_k^i}{\partial x}\ \dfrac{\partial\psi^i}{\partial x}+\dfrac{\partial N_k^i}{\partial y}\ \dfrac{\partial\psi^i}{\partial y} \\ +\mathrm{Ra}\ (\theta^i\dfrac{\partial N_k^i}{\partial x}+2\gamma\theta^{i2}(N_k^i)\dfrac{\partial N_k^i}{\partial x}+ \\ +\phi^i\dfrac{\partial N_k^i}{\partial x}) \end{pmatrix} d\Omega = \int_\Gamma N_k^i\left(\frac{\partial\psi^i}{\partial x}\ n_x+\frac{\partial\psi^i}{\partial y}n_y\right)d\Gamma_i+\int_\Gamma N_k^i n_x\theta^i d\Gamma_i \tag{3.6}$$

Accomplish (3.6) the Green's axiom is related w.r.t the rate of change of ψ on the outside touching θ particulars.

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applying (3.1) and (3.2) in (3.13) we have

$$\sum_m \psi_m^i \left\{ \int_\Omega \begin{pmatrix} (1+M^2)\frac{\partial N_k^i}{\partial x} & \frac{\partial N_m^i}{\partial x} + \\ \frac{\partial N_m^i}{\partial y} & \frac{\partial N_k^i}{\partial y} \end{pmatrix} d\Omega + Ra\left(\sum_L \theta_L^i \int_{\Omega^i} N_k^i \frac{\partial N_L^i}{\partial x} + \sum_L \theta_L^{i2}(N_k^i)\frac{\partial N_L^i}{\partial x}\right)d\Omega + \phi_L^i N \int_{\Omega^i} N_k^i \frac{\partial N_L^i}{\partial x} d\Omega) \right\}$$

$$= \int_\Gamma N_k^i \left(\frac{\partial \psi^i}{\partial x} n_x + \frac{\partial \psi^i}{\partial y} n_y \right) d\Gamma_i + \int_\Gamma N_k^i \theta^i d\Omega_i = \Gamma_k^i \qquad (3.7)$$

individually extract unalterable plexus of 10 triangular members(Fig.1). The discipline has culmination whose universal variables correlate are (1,c) , (1,0) and (0,0), in the non-geographical design. Let e_1, e_2…..e_{10} be the 10 members and let θ_1, θ_2, …..θ_{10} be the universal variable values of θ&ψ_1, ψ_2,……,ψ_{10} be the exhaustive values of ψ at the 10 general nodes of the domain (Fig.1).

4. Results and Discussions

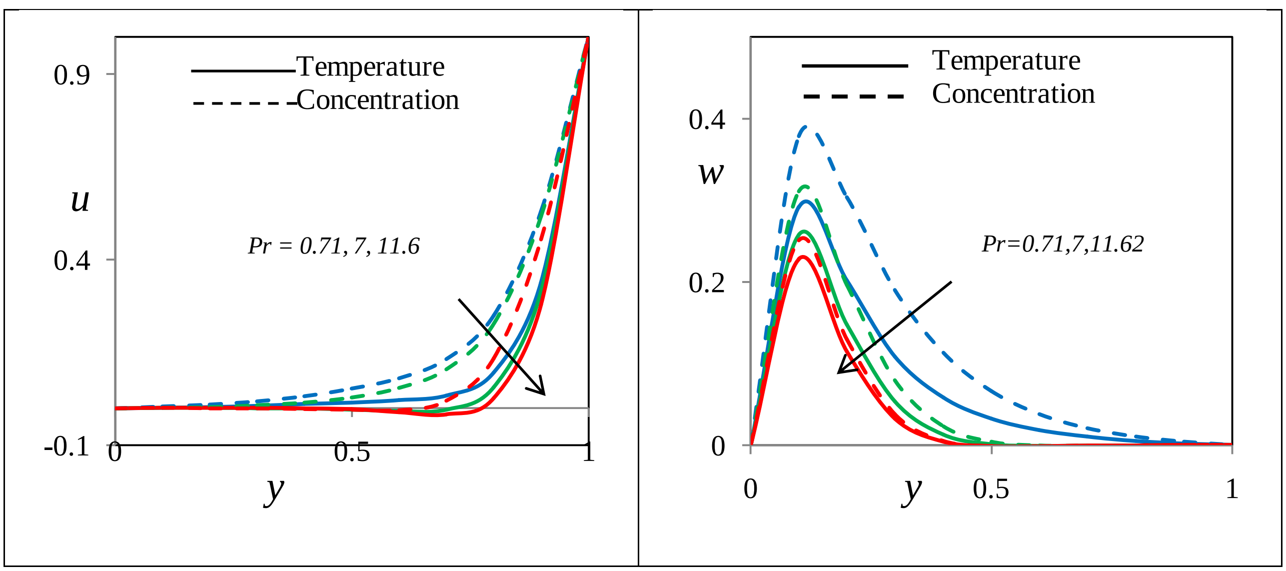

Fig.2. Influence of '*Pr*' on Temperature and concentration

Figs. 2, describe the impact of the variable *Pr* on the non dimensionality hotness and fluid combination dissemination in existence of hotness cause and capsize. It can be clearly seen from Fig. 2 that as the the parameter *Pr*effects increase, the velocity of the proceed increases.

Companionship of weak intersecting irresistible field (M = 0.1), the effects of viscous dissipation parameter Ω and magnetic *Pr* are demonstrated. We observed that a grow in dissipation parameter Ω from 1 through 3 to 5 with fixed values of *Pr* either at 0.71 or at 11.6, there is an increase in velocity profiles.

From Fig.3, parameter Pr is the communication in the middle the animated forcefulness in the flow and the total heat. It impersonates the swap of driving spirit intodomestic power by effort complete across the viscous fluid accentuation. Larger viscous destructive hotness explanation aincrease in the temperature as well as the velocity leads to change in Nu and Sh as describes the repercussion of chemical acknowledgment k_r, and *Sc* on non-structural heat.

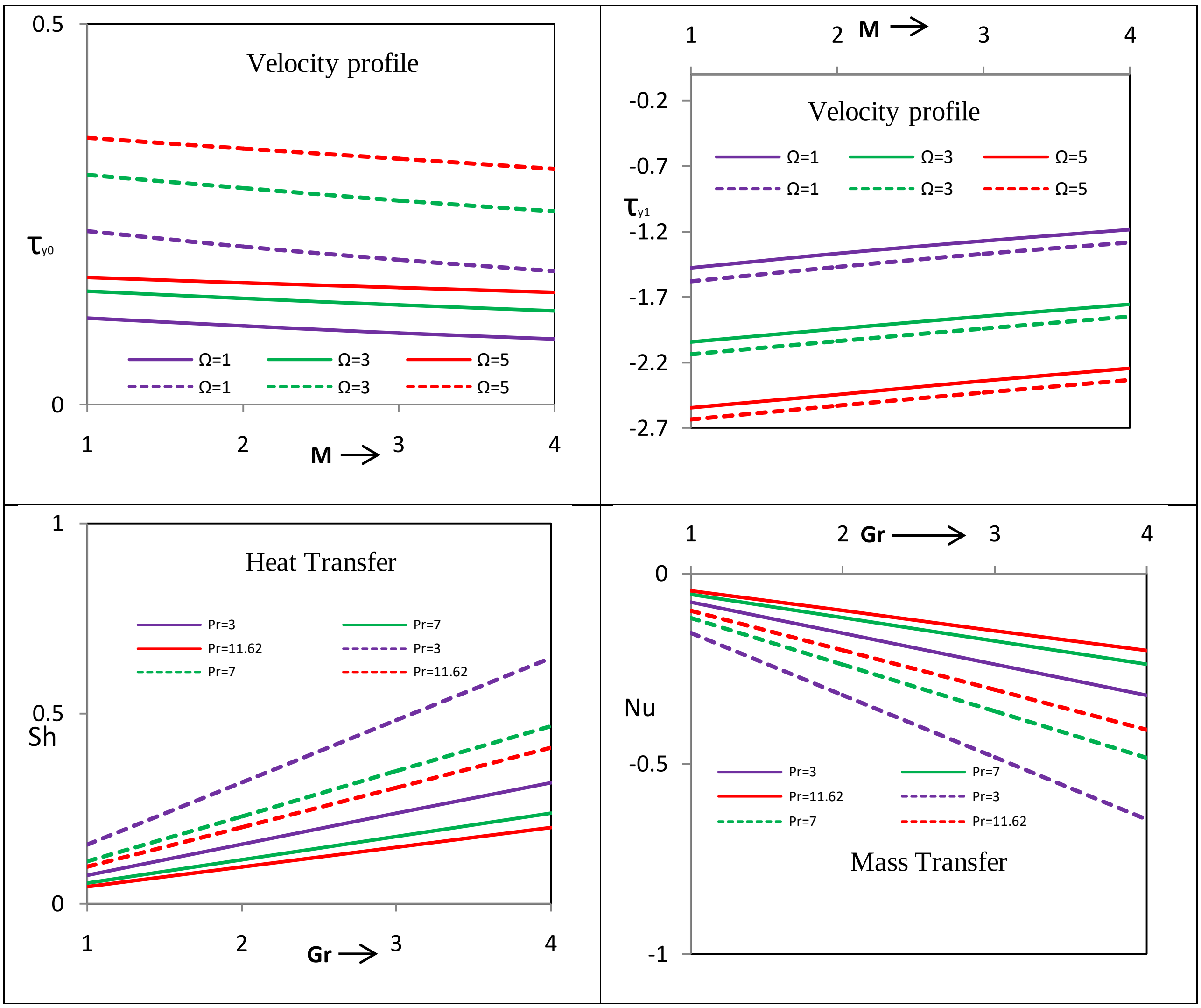

Fig.3.Variations of Shear stress τ_x Nu and Sh with various physical parameters

Table: Comparability of the instant conclusions (analytical and numerical) with Gr_m = *Gr* =1, *M*=0.1, and *Pr*=1

specifications	α	Network reproduction method			Perturbation method			FEM		
		$u'(0)$	$\theta'(0)$	$\phi'(0)$	$u'(0)$	$\theta'(0)$	$\phi'(0)$	$u'(0)$	$\theta'(0)$	$\phi'(0)$
Ec=0.1,K=0.1	-0.05	3.9047	-0.4495	-0.6870	3.9031	-0.4488	-0.6874	3.9028	-0.4485	-0.6877
Sc=0.6,Pr=0.71	0.05	4.3710	-0.1783	-0.6870	4.3699	-0.1766	-0.6874	4.3695	-0.1762	-0.6877
Ec=0.01,K=0.1	-0.05	3.7525	-0.7445	-0.6870	3.7511	-0.7429	-0.6874	3.7508	-0.7425	-0.6879
Sc=0.6,Pr=0.71	0.05	4.0589	-0.5927	-0.6870	4.0572	-0.5911	-0.6874	4.0568	-0.5907	-0.6879
Ec=0.01,K=1.0	-0.05	3.1746	-0.7543	-1.1277	3.1737	-0.7528	-1.1268	3.1733	-0.7526	-1.1257
Sc=0.6,Pr=0.71	0.05	3.4763	-0.6046	-1.1277	3.4752	-0.6031	-1.1268	3.4747	-0.6027	-1.1257
Ec=0.01,K=1.0	-0.05	2.9324	-0.5755	-1.5408	2.9303	-0.5747	-1.5411	2.9301	-0.5740	-1.5418
Sc=0.94,Pr=0.71	0.05	3.2329	-0.6085	-1.5408	3.2314	-0.6081	-1.5411	3.2310	-0.6079	-1.5418
Ec=0.01,K=1.0	-0.05	3.1268	-0.6574	-1.5408	3.1247	-0.6555	-1.5410	3.1244	-0.6551	-1.5418
Sc=0.94,Pr=0.71	0.05	3.6575	-0.4742	-1.5408	3.6561	-0.4731	-1.5410	3.6558	-0.4728	-1.5418

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5. Conclusions

(i). An increase in *Gr* (decrease in *Gc*) the fluid velocity is increased. The velocity reduction with the enlargement of *M*.An accumulation in Scthe rate of change in displacement exaggeration.

(ii). An accumulation in *Ec*&Pr we observed an enhancement in magnetic field. An accession in Sr (Declining in Du) we observed maximization in magnetic field.

(iii). Maximization in Du we observed an enhancement in temperature in the existence of heat source and scuttle. An augmentation in Du and for S>0, S<0 we observed an increase in temperature.

(iv). Greater numaricals of *Sc* volume to go down in synthesized infinitesimal diffused. Proliferate in *Sc* or *Pr*will contains description compression in the termination stratum regularity.

(v). Every vertices of the fluid region the concentration distribution diminishes with the raise in the Sc and chemical acknowledgment criterion. This exemplifies that substantial spreading category have larger postpone implement on the consolidation transportation of the flow region.

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