FINITE DIFFERENCE ANALYSIS OF MHD THREE-DIMENSIONAL HEAT AND MASS TRANSFER FLOW THROUGH A POROUS MEDIUM

***Kotagiri Srihari, , G Srinivas Reddy, *P.V.Janardan Reddy**

**Department of Mathematic, Department of Physics & Chemistry*

Mahatma Gandhi Institute of Technology,

Gandipet, Hyderabad, Telangana state, India, 500075.

Abstract

The present numerical attempt with the implementation of a finite difference technique is made to analyze the level of impact of various parameters in phenomenon of flow on free-convection flow of a viscous incompressible fluid through a porous medium bounded by an infinite vertical porous plate. A magnetic field is assumed to be implemented in avertical direction to the fluid flow. Attaining solution in a closed form for such kind of 3-D fluid flow research problems is actually of very difficult task as it is of high degree ofnon linear nature. Therefore, the problem has been solved with the implementation and approach with finite difference and perturbation methods, for which numerical simulation was made with the coding in C-Program**.** The results arrived are of good agreement with realistic situation of general practical problems in physics.

Key words:

Volumetric rate of heat absorption; Magnetic field; Porous medium; Periodic permeability; Soret number; Finite deference method

Introduction:

In the phenomenon of three-dimensional free convective flows with simultaneous heat and mass transfer has been a subject of discussion in the research circles because of its various applications in natural sciences, engineering sciences and in industry. There has been an interesting discussion of research problems in the recent past in 3-Dimensional fluid flow which is generally connected to the phenomenon consisting of mass and heat transfer. Such kind scenarios in research investigations is generally come across the situation where buoyancy will be induced motions which takes place in the atmosphere such water flows and other. Free convective flows which has various levels of permeability and taking place through maximum porous media will have an influencing impact in chemical engineering applications and other areas of technologies like aerospace technology. Flow of various characteristics are involved in variety practical applications such as oil processes of enhancement processes , geothermal reservoirs, cooling of nuclear reactors and other applications of under-ground energy transport. Because of all such scientific and engineering practical applications, a numerous research problems [1-6] have been limited to to 2-D problems in fluid flows with the consideration of parameters being constant as well as variable permeability with respect to time in the porous medium. However, there are certain situations where a 3-D fluid flow can be of significantly considered in execution of research problems in which the variation of the parameters like permeability distribution in a direction normal to that of potential flow. The influence of a normal distribution in the values of permeability for the porous medium which is bounded with plates in specific directions as per the boundary conditions were studied in the earlier research studies [7, 8]. The significant studies with magnetic field in 3-D fluid flows of variety characteristics such as a incompressibility and walls of fluid with electrical conducting nature in a normal direction of sinusoidal varying phenomenon of suction is clearly revealed in previous research problems by[9]. Hydro magnetic influences on 3-Dphinominon of oscillatory phenomenon of considered fluid flow having the nature or characteristic nature with viscosity and incompressibility of fluid which takes place in porous plate kept in normal direction to a sinusoidal varying sections [10].The impact phenomenon of periodically varying normal direction to the fluctuations of the permeability on heat and the impact of fluid on the free-convective incompressible fluid which takes place through porous medium being bounded withy the plates of porous nature in transverse directions, all re discussed clearly in earlier numerical attempts [11]. The similar and identical features in research have been explored in extensive manner with the consideration of parameter of mass transfer [12]. Analysis ismade on the influences of periodical fluctuations and variations in the parameters of temperature as well as periodically changing permeability on 3-Dfluid flow with the nature of free convective in a porous medium is made in previous numerical research problems[14]. The nature of impact of magnetic field on 3-D fluid flow with a free-convective nature in view of heat and mass transfer phenomenon in a a porous flow in a medium with changes of periodicity of permeability has been clearly discussed with profile plots [15]. Analytical solution of 3-D problem with consideration of mixed convective flow with the involvement of a significant feature of mass transfer in the vertical direction of porous plate in influencing field of applied magnetic field is obtained. Significant impact of heat sink is analyzed clearly with the involvement of magnetic field on 3-D system of free convective phenomenon of both parameters of heat as well as mass transfer in considered porous medium with the periodic changes of permeability. An extensive analysis and investigation is carried out on the 3-D flow with various features and parameters such as viscouity specific boundary conditions in order to get optimum influence of heat generation.

A significant point to be noted is that efforts applied in the earlier studies have been focussed on obtaining an analytical solution. And also numerical attempts, which relate to 3-D flow problems, have been confined to these limitations. Therefore the attempt in present paper is aims at getting the Finite difference solution of 3-D system involving free-convection flow of a viscous incompressible fluid through a porous medium bounded by an infinite vertical porous plate

Mathematical analysis:

The flow of a viscous incompressible fluid through a highly porous medium bounded by an infinite vertical porous plate with constant suction is considered. The plate is lying vertically on the x^*-z^* plane with x^*-axis taken along the plate in the upward direction. The y^*-axis is taken perpendicular to the plane of plate and directed into the fluid flowing laminarly with a uniform free stream velocity U. Since the plate consider infinite in x^* -direction, so all physical quantities are independent of x^*. A magnetic field of is applied normal to the flow, along y^* -axis. Thus, denoting velocity components by u^*, v^*, w^* in the directions of x^*, y^*, z^* respectively and the temperature by the T^* and concentration by C^*, the flow through a highly porous medium is governed by following non-dimensional equations:

$$\frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0 \tag{1}$$

$$v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} = Gr\,\mathrm{Re}\,\theta + Gm\,\mathrm{Re}\,\phi + \frac{1}{\mathrm{Re}}\left(\frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2}\right) - \frac{(u-1)\,(1+\varepsilon\cos\pi z)}{\mathrm{Re}\,K_0} - \frac{M^2}{\mathrm{Re}}u \tag{2}$$

$$v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}=-\frac{\partial p}{\partial y}+\frac{1}{\mathrm{Re}}\left(\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}\right)-\frac{(1+\varepsilon\cos\pi z)\,v}{\mathrm{Re}\,K_0} \quad (3)$$

$$v\frac{\partial w}{\partial y}+w\frac{\partial w}{\partial z}=-\frac{\partial p}{\partial z}+\frac{1}{\mathrm{Re}}\left(\frac{\partial^2 w}{\partial y^2}+\frac{\partial^2 w}{\partial z^2}\right)-\frac{(1+\varepsilon\cos\pi z)w}{\mathrm{Re}\,K_0}-\frac{M^2}{\mathrm{Re}}w \quad (4)$$

$$v\frac{\partial \theta}{\partial y}+w\frac{\partial \theta}{\partial z}=\frac{1}{\mathrm{Re}\,\mathrm{Pr}}\left(\frac{\partial^2 \theta}{\partial y^2}+\frac{\partial^2 \theta}{\partial z^2}\right) \quad (5)$$

$$v\frac{\partial \phi}{\partial y}+w\frac{\partial \phi}{\partial z}=\frac{1}{\mathrm{Re}\,Sc}\left(\frac{\partial^2 \phi}{\partial y^2}+\frac{\partial^2 \phi}{\partial z^2}\right)+\frac{So}{\mathrm{Re}}\left(\frac{\partial^2 \theta}{\partial y^2}+\frac{\partial^2 \theta}{\partial z^2}\right)-Ch\phi \quad (6)$$

The corresponding boundary conditions reduce to

$$y=0;\ u=0,\ v=-1,\ w=0,\ \theta=1,\ \phi=1 \quad (7)$$

$$y\to\infty;\ u\to 1,\ w\to 1,\ p\to p_\infty,\ \theta\to 0,\ \phi\to 0$$

Where

$Gr=\dfrac{\upsilon g\beta\left(T_w^*-T_\infty^*\right)}{UV^2}$ (Grashof number), $So=\dfrac{D_T(T_w-T_\infty)}{\upsilon(C_w-C_\infty)}$ (Soret number),

$Gm=\dfrac{\upsilon g\beta^*\left(C_w^*-C_\infty^*\right)}{UV^2}$ (Modified Grashof number)

$\mathrm{Re}=\dfrac{VL}{\upsilon}$ (Reynolds number), $\mathrm{Pr}=\dfrac{\mu C_p}{k}$ (Prandtl number)

$Sc=\dfrac{\upsilon}{D}$ (Schmidt number), $K_0=\dfrac{K_0^*}{L^2}$ (Permeability parameter)

$M=B_0L\sqrt{\dfrac{\sigma}{\mu}}$ (Magnetic parameter), $Ch=\dfrac{\overline{Ch}.L}{V}$ (Chemical reaction parameter) **,**

$K^*(z^*)=\dfrac{K_0^*}{(1+\varepsilon\cos\pi z^*/L)}$ (Permeability of the porous medium)

$$y=\frac{y^*}{L},\quad u=\frac{u^*}{U},\ v=\frac{v^*}{V},\ w=\frac{w^*}{V},\ p=\frac{p^*}{\rho U^2},$$

$$\theta=\frac{T^*-T_\infty^*}{T_w^*-T_\infty^*},\qquad \phi=\frac{C^*-C_\infty^*}{C_w^*-C_\infty^*}$$

Here problem is three-dimensional due to permeability variation.

Method of solution

To solve the above equations with boundary condition, solutions of the equations (1) to (6) are assumed: $f(y, z) = f_0(y) + \varepsilon\, f_1(y,z) + \varepsilon^2 f_2(y,z) + ...$ (8)

Where f stands for u, v, w, p, θ and ϕ.

Using (8) in the equations (1) to (6) and equating the co-efficient of like **powers** of ε, and ignoring the higher powers of ε, the following set of the differential equations are obtained:

Case (i): Zeroth order equations for ε=0

$$\frac{dv_0}{dy} = 0 \quad (8) \qquad \frac{d^2u_0}{dy^2} - v_0 \operatorname{Re}\frac{du_0}{dy} - \left(M^2 + \frac{1}{K_0}\right)u_0 = -Gr\operatorname{Re}^2\theta_0 - Gm\operatorname{Re}^2\phi_0 - \frac{1}{K_0} \quad (9)$$

$$\frac{d^2\theta_0}{dy^2} - v_0 \operatorname{Re}\Pr\frac{d\theta_0}{dy} = 0 \quad (10)$$

$$\frac{d^2\phi_0}{dy^2} - v_0 \operatorname{Re} Sc\frac{d\phi_0}{dy} - Ch.\operatorname{Re}.Sc.\phi_0 = -So\, Sc\, \frac{d^2\theta_0}{dy^2} \quad (11)$$

The relevant conditions reduces to

$$y = 0;\ u_0 = 0,\ v_0 = -1,\ \theta_0 = 1,\ \phi_0 = 1 \quad (12)$$

$$y \to \infty;\ u_0 \to 1,\ p_0 \to p_\infty,\ \theta_0 \to 0,\ \phi_0 \to 0$$

Case (ii): First order equations for $\varepsilon \neq 0$

$$\frac{\partial v_1}{\partial y} + \frac{\partial w_1}{\partial z} = 0 \quad (13)$$

$$v_1\frac{\partial u_0}{\partial y} - \frac{\partial u_1}{\partial y} = Gr\operatorname{Re}\theta_1 + Gm\operatorname{Re}C_1 + \frac{1}{\operatorname{Re}}\left(\frac{\partial^2 u_1}{\partial y^2} + \frac{\partial^2 u_1}{\partial z^2}\right) - \frac{(u_0 - 1)\varepsilon\cos\pi z + u_1}{\operatorname{Re}K_0} - \frac{M^2}{\operatorname{Re}}u_1 \quad (14)$$

$$-\frac{\partial v_1}{\partial y} = -\frac{\partial p_1}{\partial y} + \frac{1}{\operatorname{Re}}\left(\frac{\partial^2 v_1}{\partial y^2} + \frac{\partial^2 v_1}{\partial z^2}\right) - \frac{(v_1 - \cos\pi z)}{\operatorname{Re}K_0} \quad (15)$$

$$-\frac{\partial w_1}{\partial y} = -\frac{\partial p_1}{\partial z} + \frac{1}{\operatorname{Re}}\left(\frac{\partial^2 w_1}{\partial y^2} + \frac{\partial^2 w_1}{\partial z^2}\right) - \frac{w_1}{\operatorname{Re}K_0} - \frac{M^2}{\operatorname{Re}}w_1 \quad (16)$$

$$v_1 \frac{\partial \theta_0}{\partial y} - \frac{\partial \theta_1}{\partial y} = \frac{1}{\text{Re}\,\text{Pr}}\left(\frac{\partial^2 \theta_1}{\partial y^2} + \frac{\partial^2 \theta_1}{\partial z^2}\right) \tag{17}$$

$$v_1 \frac{\partial \phi_0}{\partial y} - \frac{\partial \phi_1}{\partial y} = \frac{1}{\text{Re}\,Sc}\left(\frac{\partial^2 \phi_1}{\partial y^2} + \frac{\partial^2 \phi_1}{\partial z^2}\right) + \frac{So}{\text{Re}}\left(\frac{\partial^2 \theta_1}{\partial y^2} + \frac{\partial^2 \theta_1}{\partial z^2}\right) - Ch\phi_1 \tag{18}$$

The boundary conditions are:

$$y = 0;\ u_1 = 0,\ v_1 = 0,\ w_1 = 0,\ \theta_1 = 0,\ \phi_1 = 0 \tag{19}$$

$$y \to \infty;\ u_1 \to 0,\ w_1 \to 0,\ p_1 \to 0,\ \theta_1 \to 0,\ \phi_1 \to 0$$

The solutions of the equations (9) to (11) under the boundary conditions (12) are

$$u_0 = (L_0 + L_1 - 1)e^{-r_3 y} - L_0 e^{-r_1 y} - L_1 e^{-r_2 y} + 1 \tag{20}$$

$$\theta_0 = e^{-r_1 y} \tag{21}$$

$$\phi_0 = (1 + a_1)e^{-r_2 y} - a_1 e^{-r_1 y} \tag{22}$$

with

$$v_0 = -1,\ w_0 = 0 \text{ and } p_0 = p_\infty \tag{23}$$

Where

$$a_1 = \frac{r_1^2\ So\ Sc}{r_1^2 - \text{Re}\,Sc\,r_1 - Ch\ \text{Re}\ Sc}, \qquad L_0 = \frac{(Gr - Gm a_1)\text{Re}^2}{r_1^2 - \text{Re}\,r_1 - \left(M^2 + \frac{1}{K_0}\right)}$$

$$L_1 = \frac{(1 + a_1)\,Gm\ \text{Re}^2}{r_2^2 - \text{Re}\,r_2 - \left(M^2 + \frac{1}{K_0}\right)},\ r_1 = \frac{\text{Re}\,\text{Pr} + \sqrt{\text{Re}^2\,\text{Pr}^2}}{2} \tag{24}$$

$$r_2 = \frac{\text{Re}\,Sc + \sqrt{\text{Re}^2\,Sc^2 + 4Ch\ \text{Re}\ Sc}}{2}, \qquad r_3 = \frac{\text{Re} + \sqrt{\text{Re}^2 + 4\left(M^2 + \frac{1}{K_0}\right)}}{2} \qquad \textbf{(24)}$$

In order to solve equations (13) to (18), the variables y and z are separated in the following manner.

$$v_1(y, z) = -v_{11}(y)\cos\pi z \tag{25}$$

$$w_1(y, z) = \frac{1}{\pi} v'_{11}(y)\sin\pi z \tag{26}$$

$$p_1(y, z) = p_{11}(y)\cos\pi z \tag{27}$$

Making use of equations (25), (26) and (27) in equations (15) and (16) and eliminating the terms p'_{11}, p_{11}, we have

$$\frac{d^4 v_{11}}{dy^4} + \mathrm{Re}\frac{d^3 v_{11}}{dy^3} - \left(M^2 + \frac{1}{K_0} + 2\pi^2\right)\frac{d^2 v_{11}}{dy^2} - \mathrm{Re}\,\pi^2 \frac{dv_{11}}{dy} + \left(\pi^4 + \frac{\pi^2}{K_0}\right)v_{11} = -\frac{\pi^2}{K_0} \quad (28)$$

The corresponding boundary conditions become

$$\begin{aligned} &y = 0 : v_{11} = 0,\ v'_{11} = 0 \\ &y \to \infty : v_{11} = 0 \end{aligned} \quad (29)$$

Substituting, $u_1(y,z) = u_{11}(y)\cos\pi z,\ \theta_1(y,z) = \theta_{11}(y)\cos\pi z,\ C_1(y,z) = C_{11}(y)\cos\pi z$.

in (14), (17) and (18),the following are obtained

$$\frac{d^2 u_{11}}{dy^2} + \mathrm{Re}\frac{du_{11}}{dy} - \left(M^2 + \frac{1}{K_0} + \pi^2\right)u_{11} = -\mathrm{Re}\,v_{11}\frac{du_0}{dy} - Gr\,\mathrm{Re}^2\,\theta_{11} - Gm\,\mathrm{Re}^2\,\phi_{11} + \frac{u_0 - 1}{K_0} \quad (30)$$

$$\frac{d^2\theta_{11}}{dy^2} + \mathrm{Re}\,\mathrm{Pr}\frac{d\theta_{11}}{dy} - (\pi^2)\theta_{11} = -\mathrm{Re}\,\mathrm{Pr}\,v_{11}\frac{d\theta_0}{dy} \quad (31)$$

$$\frac{d^2\phi_{11}}{dy^2} + \mathrm{Re}\,Sc\frac{d\phi_{11}}{dy} - (Ch\,\mathrm{Re}\,Sc + \pi^2)\phi_{11} = -\mathrm{Re}\,Sc\,v_{11}\frac{d\phi_0}{dy} - So\,Sc\left(\frac{d^2\theta_{11}}{dy^2} - \pi^2\theta_{11}\right) \quad (32)$$

The corresponding boundary conditions becomes

$$y = 0 : \quad u_{11} = 0,\ \theta_{11} = 0,\ \phi_{11} = 0 \quad (33)$$

$$y \to \infty : u_{11} \to 0,\ \theta_{11} \to 0,\ \phi_{11} \to 0\,.$$

Substitution of the following finite difference formulae

$$\frac{d^2 v_{11}}{dy^2} = \frac{v_{11}(i+1) - v_{11}(i-1)}{2h}, \quad \frac{d^2 v_{11}}{dy^2} = \frac{v_{11}(i+1) - 2v_{11}(i) + v_{11}(i-1)}{h^2}$$

$$\frac{d^3 v_{11}}{dy^3} = \frac{v_{11}(i+2) - 2v_{11}(i+1) + 2v_{11}(i-1) - v_{11}(i-2)}{2h^3}$$

$$\frac{d^4 v_{11}}{dy^4} = \frac{v_{11}(i+2) - 4v_{11}(i+1) + 6v_{11}(i) - 4v_{11}(i-1) + v_{11}(i-2)}{h^4}$$

in equation (28) gives the following

$$A_1 v_{11}(i+2) - A_2 v_{11}(i+1) + A_3 v_{11}(i) - A_4 v_{11}(i-1) + A_5 v_{11}(i-2) = -2\frac{\pi^2 h^4}{K_0} \quad (34)$$

The corresponding boundary conditions in finite difference form are given by:

$$v_{11}[i]=0, \quad for \quad i=0$$
$$v_{11}[i]=0, \quad for \quad i=10 \qquad \textbf{(35)}$$

where $A_1 = 2+\operatorname{Re}h$, $A_2 = 8+2\operatorname{Re}h+2h^2\left(M^2+\frac{1}{K_0}+2\pi^2\right)+\operatorname{Re}h^3\pi^2$

$$A_3 = 12+4h^2\left(M^2+\frac{1}{K_0}+2\pi^2\right)+2h^4\left(\pi^4+\frac{\pi^2}{K_0}\right)$$

$$A_4 = 8-2\operatorname{Re}h+2h^2\left(M^2+\frac{1}{K_0}+2\pi^2\right)-\operatorname{Re}h^3\pi^2, \quad A_5 = 2-\operatorname{Re}h.$$

Similarly substituting of the following finite difference formulae

$$\frac{du_{11}}{dy}=\frac{u_{11}(i+1)-u_{11}(i-1)}{2h},$$

$$\frac{d^2u_{11}}{dy^2}=\frac{u_{11}(i+1)-2u_{11}(i)+u_{11}(i-1)}{h^2}$$

$$\frac{d\theta_{11}}{dy}=\frac{\theta_{11}(i+1)-\theta_{11}(i-1)}{2h}$$

$$\frac{d^2\theta_{11}}{dy^2}=\frac{\theta_{11}(i+1)-2\theta_{11}(i)+\theta_{11}(i-1)}{h^2}$$

$\frac{d^2\phi_{11}}{dy^2}=\frac{\phi_{11}(i+1)-2\phi_{11}(i)+\phi_{11}(i-1)}{h^2}$, in equations (30) to (32), the following are obtained:

$$A_1u_{11}(i+1)-A_6u_{11}(i)+A_5u_{11}(i-1)=A(i) \qquad (36)$$

$$B_1\theta_{11}(i+1)-B_2\theta_{11}(i)+B_3\theta_{11}(i-1)=B(i) \qquad (37)$$

$$C_1\phi_{11}(i+1)-C_2\phi_{11}(i)+C_3\phi_{11}(i-1)=C(i) \qquad (38)$$

The boundary conditions in finite difference form are given by:

$$u_{11}[i]=0,\ \theta_{11}[i]=0, \Phi_{11}[i]=0 \ \ for \ \ i=0$$
$$\boldsymbol{u_{11}[i]=0,\ \theta_{11}[i]=0, \Phi_{11}[i]=0 \ for \ i=10}$$

where i stands plate divisions with step length h =0.1 and $y=i\,h$, and A_1, A_5, L_0, L_1 have already been defined and

$$B_1 = 2 + \text{Re}\,\text{Pr}\,h,\; B_2 = 4 + 2h^2\pi^2$$

$$B_3 = 2 - \text{Re}\,\text{Pr}\,h,\; B(i) = 2h^2 r_1\,\text{Re}\,\text{Pr}\,v_{11}(i)e^{-r_1 ih}$$

$$C_1 = 2 + \text{Re}\,Sch,\; C_3 = 2 - \text{Re}\,Sc\,h$$

$$C_2 = 4 + 2h^2(\pi^2 + Ch\,\text{Re}\,Sc),\; A_6 = 4 + 2h^2\left(M^2 + \frac{1}{K_0} + \pi^2\right)$$

$$C(i) = 2h^2\,\text{Re}\,Scv_{11}(i)\left((1+a_1)r_2e^{-r_2y} - a_1r_1e^{-r_1y}\right) - 2\,So\,Sc\left(\theta_{11}(i+1) - (2+\pi^2h^2)\theta_{11}(i) + \theta_{11}(i-1)\right)$$

$$A(i) = -2h^2\,\text{Re}\,v_{11}(i)A_7(i) - 2(h\,\text{Re})^2\left(Gr\theta_{11}(i) - Gm\phi_{11}(i)\right) + \frac{2h^2}{K_0}A_8(i)$$

$$A_7(i) = L_0\left(r_1e^{r_1y} - r_3e^{-r_3y}\right) + L_1\left(r_2e^{r_2y} - r_3e^{-r_3y}\right) + \frac{r_3e^{-r_3y}}{M^2 + \frac{1}{K_0}}$$

$$A_8(i) = L_0\left(e^{r_3y} - r_3e^{-r_1y}\right) + L_1\left(e^{r_3y} - e^{-r_3y}\right) - \frac{e^{-r_3y}}{M^2 + \frac{1}{K_0}} + \left(\frac{1}{M^2 + \frac{1}{K_0}} - 1\right)$$

Equations (34),(36),(37) and (38) with corresponding boundary conditions have been solved by using Gauss-seidel iteration method for which simulation is carried out by coding in C-Program**.** In order to establish the convergence of the technique of finite difference scheme, the computation been performed with updated and modifications in the values of h and the iterations have made until a **tolerance** 10^{-8} is reached. No significant variation in the values of has been observed for the parameters $u, \theta\ and\ \phi$ that have been taken to the present simulation. Thus, it is concluded that the finite difference scheme is convergent and stable.

Nomenclature		
g	–	Acceleration due to gravity
β	–	Coefficient of volumetric thermal expansion
β^*	–	Coefficient of mass expansion
p^*	–	Pressure

ρ	–	Density
υ	–	Kinematics viscosity
μ	–	Viscosity
k	–	Thermal conductivity
C_p	–	Specific heat at constant pressure
D	–	Concentration diffusivity
C_w^*	–	Concentration of the plate
T_w^*	–	Temperature of the plate,
T_∞^*	–	Temperature of the fluid far away from the plate
C_∞^*	–	Concentration of the fluid far away from the plate
B_0		Magnetic field component

Results and discussion:

For a significant interpretation, the effects in the study through different parameters which involve in the numerical simulation of present attempt for the distribution of various factors like the concentration profile, profile of velocity, variation of temperature, across considered the boundary layer for different levels of values which are taken and assigned to flow parameters is executed in the investigation.

The influence of different parameters like changes in Soret number on the profile of velocity and field variation profile and concentration is depicted clearly in figures (1) and (4) respectively. The Soret number which defines and convey the influence and impact level of the temperature gradients, inducing significant mass diffusion effects. It is significantly observed and clearly noted that the enhancement in the value of Soret number, which may lead to increase in the value of velocity. It is also conveyed from figure (4) that the solutal boundary layer thickness increases with the increasing values of Soret number. As Rising Soret number shows a reduce in the viscosity of the fluid. It leads to increased inertia effects and weakened viscous effects. Consequently the concentration and velocity of the fluid increase

From fig (2), an interesting point to be noted that the increase in the values of permeability parameter may cause an increase in the velocity of the flow .Fig (5) depictsthe influence of magnetic parameter M on velocity field u. It can be inferred from figure that an increase in M leads to decrease in the velocity. This because of the fact that the presence of transverse magnetic field in the fluid having an electrically conducting nature generally causes barrier phenomenon of force of resistive nature which is generally called a Lorentz force acting in a opposite direction to the fluid flow. The force that has an opposing nature will cause the motion with slow velocity of the fluid and therefore a decrease in the velocity profiles is a general result. The result that is achieved in the simulation process will be well coincidence of the facts which are expected. From these it is observed that concentration of the fluid decreases for the increasing values of the Ch. The attained solutions in terms of values present a good agreement with realistic situations that are generally come across in the practical problems of physics. The figures (5) convey and depict the variation of influence of chemical reaction (Ch) on the profile of concentration of field constituted and indicated with curved lines.

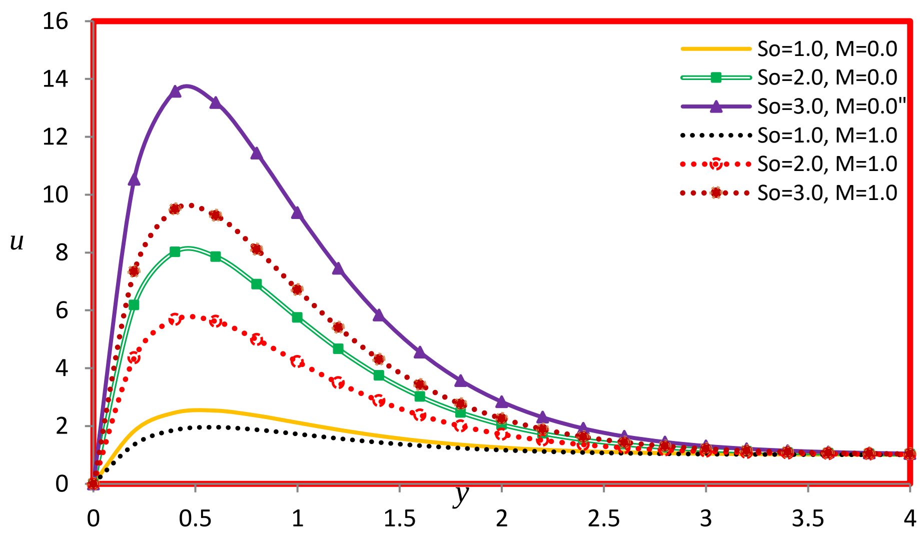

Fig.1-Effect of So on velocity field u in the presence of magnetic field
(Gr=5.0, Gm=1.0, Re=2.0, Pr=0.71, Sc=0.66, Ko=1.0, Ch=0.5, ε=0.1 and Z=0.0)

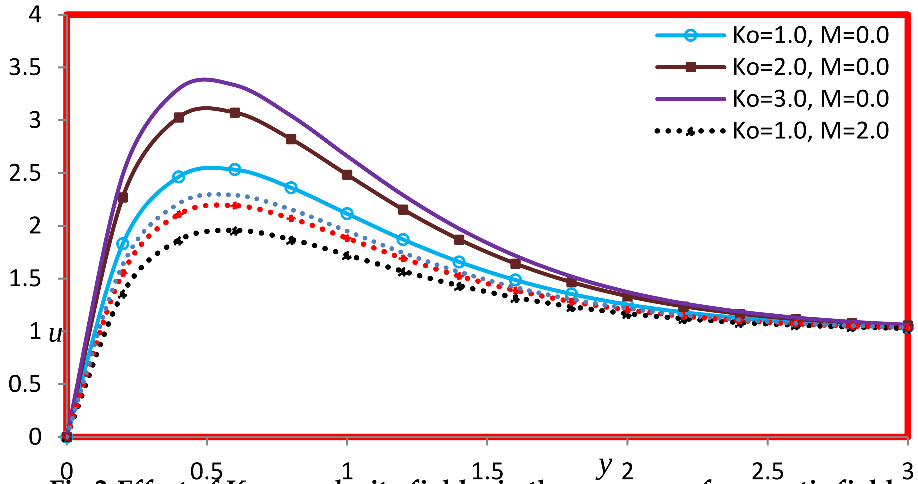

Fig 2-Effect of Ko on velocity field u in the presence of magnetic field
(Gr=5.0,Gm=1.0, Re=2.0, So=1.0, Pr=0.71, Sc=0.66, Ch=0.5, ε=0.1 and Z=0.0)

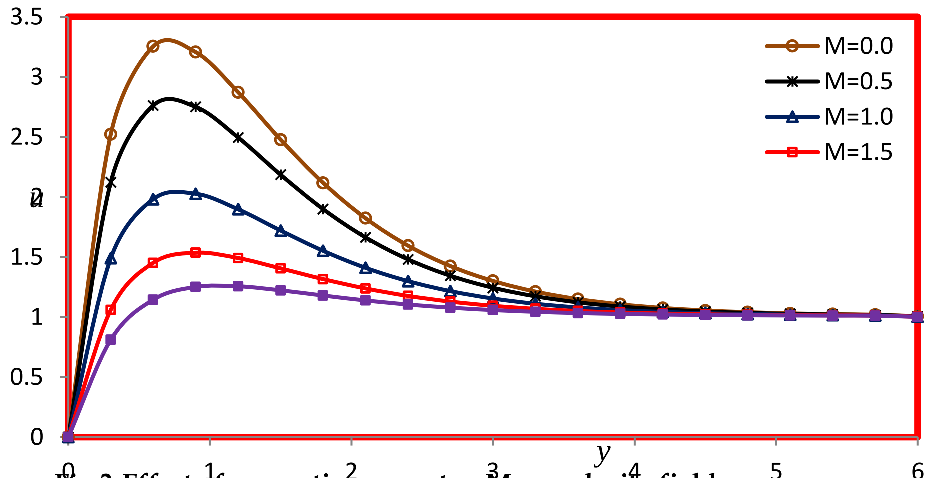

Fig 3-Effect of magnetic parameter, M on velocity field u
(Gr=5.0, Gm=1.0, Re=2.0, Ko=1.0, So=1.0, Pr=0.71, Sc=0.66, Ch=0.5, ε=0.1 and Z=0.0)

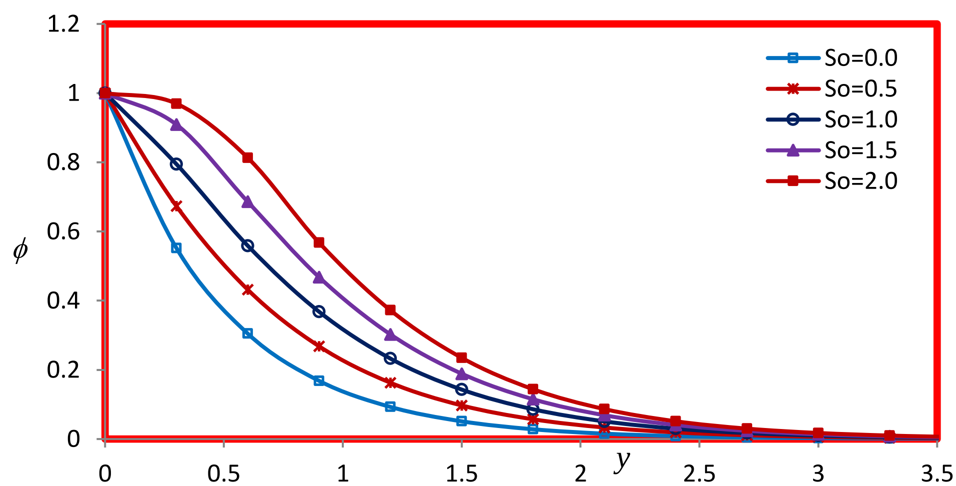

Fig 4-Effect of Thermal-diffusion on Concentration field
(Pr=0.71, Sc=0.66, Re=2.0, Ko=1.0, Ch=0.5, M=1.0, ε=0.1 and Z=0.0)

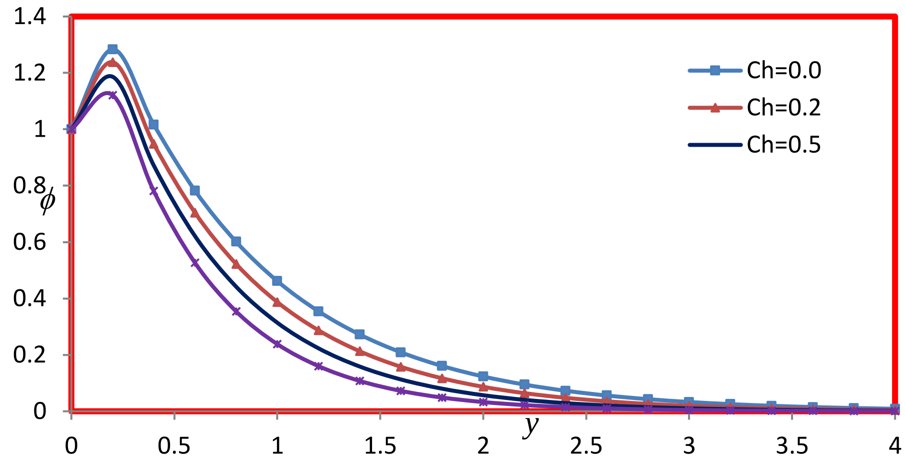

Fig 5-Effect of chemical reaction on Concentration field
(Pr=0.71, Sc=0.66, So=1.0, Re=2.0, Ko=1.0, M=1.0, ε=0.1 and Z=0.0)

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