Chemical Reaction Effect on Magnetite Nano Fluid through Permeable Surface

N. Vedavathi, G. Dharmaiah, K.S. Balamurugan, M. Sreenivasa Kumar, W. Sridhar

***Abstract*: The transient MHD stream of a Fe_3O_4 water based nano flow fluid past moving vertical holey semi-infinite holey surface and convective in the company of chemical reaction, thermophoresis and consistent heat basis in a turning casing of orientation is examined. The platter is considered to waver in moment with steady recurrence. The impacts of parameters entering into the problem inside the periphery layer for the stream, temperature and concentration are analyzed for magnetite water based nanofluid through diagrams.**

***Key Words:* Chemical Reaction, MHD, Rotating Frame, Soret effect, Transient.**

I. INTRODUCTION

Magnetite nanoparticles are orchestrated by means of co-precipitation method from ferrous and ferric arrangements. The exponential development of the investigation of nano fluids made the most recent innovation progressively advantageous and easy to use. Seeing that the nano flow fluids conveys the clanging molecule the heat transmit as well as dispersion jointly is an intriguing wonder through large application with regards to the pasture of biomedical, medicate conveyance and so forth. At hand, several applications of hydro charismatic fluid flow of non-Newtonian liquids in a revolving body in environmental, solar and a few different zones. The investigation of nano fluid pulled in numerous explores since [1] in view of its essential applications. Moreover, these are having numerous applications inside bio-medical, for example, blood stream inside vessels, and dialysisalization of blood in counterfeit kidney as well as stream in blood oxygenations. Revolving flow of MHD fluids has several applications in geo-physics and numerous kinds. Such fluids within the sight of a charismatic kinds are noteworthy for the reason that, their astrophysical

significance as well as contributed by the scientist [2]. The transport marvels in permeable media have been of proceeding with enthusiasm for as far back as decades. This is because of its wide applications sunlight based recipient gadgets, heat exchangers, vitality stockpiling units, clay preparing, and synergist reactors to give some examples. Moreover, nano flows have been additionally utilized in permeable media because of their predominant thermal qualities. Permeable media increment the contact surface region among fluid and strong surface, and, then again, nanoparticles scattered in nano flows improve the successful thermal conductivity. Then again, using permeable media in heat exchangers is another strategy to expand of thermal productivity. Permeable media by giving high surface territory contact will enhance heat transmit speed in channels. Regular convection of periphery layer of a permeable medium nano flows issues were made by ([3] & [4]). Over a decades ago, various works have detailed [5] on the thermal conductivity of nano flows than that of customary heat transmit liquids with the reason of arbitrary movement of nano particles. The warmth cause or descend impacts in radiative convection, are critical somewhere at hand may exist a elevated heat contrasts between the surface (for example breathing space specialty) along with encompassing liquid. As of late, free convective MHD stream within a pivoting edge of position with consistent heat supply in a nano flow fluid introduced by [6]. For the most part, it's be realized that heat and bunch transitions be made from heat and concentration gradients, individually. Be that as it may, heat fluctuation is really preserve exist because of the concentration slope which is identified as Soret impact. Convective free stream of micro-polar fluids into a turning casing of orientation detailed given by ([7], [8]).

Present paper deals the investigation to break down the improvement of the transient free convective stream of Fe_3O_4 nano flows a moving past vertical porous semi-unbounded flat platter. It is accepted that the platter is
implanted in a consistent permeable medium along with aways in time with a steady recurrence within the sight of a crossways magnetic field. So, principle point of this examination is to extend the exertion of reference Kalidas Das [9] toward the path to consider the mass effects.

II. MATHEMATICAL MODEL

A transient 3 – D progression of an electrically conducting incompressible nano flow a semi-interminable vertical holey plate is supposed. Owing to semi- interminable shield plane suspicion the flow variables are functions of z and time t & without slip occurred between them. Assumed boundary layer conditions are:

$$\frac{\partial w^*}{\partial z^*} = 0 \tag{1}$$

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$$\frac{\partial u^*}{\partial t^*}+w^*\frac{\partial u^*}{\partial z^*}-2\Omega v^*=\left[\rho_{nf}\right]^{-1}\left[\begin{array}{l}\mu_{nf}\dfrac{\partial^2 u^*}{\partial z^{*2}}+\\ {[\rho\beta]_{nf}}\, g\left[T-T_\infty\right]\end{array}\right] \quad (2)$$

$$-\frac{1}{\rho_{nf}}\sigma B_0^2 u^*-\frac{\mu_{nf}}{\rho_{nf}}\frac{u^*}{k}$$

$$\frac{\partial v^*}{\partial t^*}+w^*\frac{\partial v^*}{\partial z^*}+2\Omega u^*=\frac{\mu_{nf}}{\rho_{nf}}\frac{\partial^2 v^*}{\partial z^{*2}}-\frac{1}{\rho_{nf}}\sigma B_0^2 v^*-\frac{\mu_{nf}}{\rho_{nf}}\frac{v^*}{k} \quad (3)$$

$$\frac{\partial T}{\partial t^*}+w^*\frac{\partial T}{\partial t^*}=\alpha_{nf}\frac{\partial^2 T}{\partial z^{*2}}-\frac{\left[T-T_\infty\right]}{[\rho Cp]_{nf}}Q^* \quad (4)$$

$$\frac{\partial C}{\partial t^*}+w^*\frac{\partial C}{\partial z^*}=D_B\frac{\partial^2 C}{\partial z^{*2}}-K_l\left[C-C_\infty\right]+\left[T_m\right]^{-1}D_m\, k_T\frac{\partial^2 T}{\partial z^{*2}} \quad (5)$$

Proposed limit conditions are composed as

$$u^*(z^*,t^*)=0,\ v^*(z^*,t^*)=0,\ T=T_\infty,\ C=C_\infty \quad \text{for } t^*\le 0 \text{ and any } z^* \quad (6)$$

$$\left.\begin{array}{l} u^*(\infty,t^*)=\left[1+\dfrac{\varepsilon}{2}\left(e^{i n^* t^*}+e^{-i n^* t^*}\right)\right]U_0,\\ v^*(\infty,t^*)=0,-k_{nf}\dfrac{\partial T}{\partial z^*}=\left[T_w-T_\infty\right]h_f,\\ C=C_w \quad at\ z^*=0\\ u^*\to 0,\ v^*\to 0,\ T\to T_\infty,\ C\to C_\infty\\ \quad as\ z^*\to\infty \end{array}\right\} \text{for } t^*\ge 0 \quad (7)$$

Respective velocity components along the 3-directions are u*, v* and w*. Properties of nano-fluids which are specified by [10] and Thermo substantial properties of H_2O and considered different nano-fluids are [11].

$$\begin{array}{l} \rho_{nf}=\phi\,\rho_s+[1-\phi]\rho_f,\\ \left[\rho\, Cp\right]_{nf}=\phi\,(\rho Cp)_s+[1-\phi]\left[\rho Cp\right]_f,\\ (\rho\beta)_{nf}=(1-\phi)(\rho\beta)_f+\phi(\rho\beta)_s,\\ \mu_{nf}=\dfrac{\mu_f}{[1-\phi]^{2.5}},\quad \alpha_{nf}=\dfrac{K_{nf}}{(\rho Cp)_{nf}},\\ K_{nf}=\left[K_s+2K_f+2\phi\left[K_f-K_s\right]\right]^{-1}\\ .K_f\left[K_s+2K_f-2\phi\left[K_f-K_s\right]\right] \end{array} \quad (8)$$

Solution of Eq. (1) is considered as $w^*=-w_0$ (9)

Introducing dimensionless variables in the following manner:

$$\begin{array}{l} u=\dfrac{u^*}{U_0},\ v=\dfrac{v^*}{U_0},\quad z=\dfrac{z^* U_0}{\nu_f},\ t=\dfrac{t^* U_0^2}{\nu_f},\\ n=\dfrac{\nu_f n^*}{U_0^2},\ S=\dfrac{w_0}{U_0},\ R=\dfrac{2\Omega\nu_f}{U_0^2},\ Q_H=\dfrac{Q^*\nu_f^2}{K_f U_0^2},\\ \Pr=\dfrac{\nu_f}{\alpha_f},\ \theta=\dfrac{T-T_\infty}{T_w-T_\infty},\ \psi=\dfrac{C-C_\infty}{C_w-C_\infty},\\ M=\dfrac{\sigma B_0^2\nu_f}{\rho_f U_0^2},\ K=\dfrac{k\rho_f U_0^2}{\nu_f^2},\ Kr=\dfrac{K_l\nu_f}{U_0^2},\\ Sc=\dfrac{\nu_f}{D_B},\ Sr=\dfrac{D_m k_T(T_w-T_\infty)}{T_m\nu_f(C_w-C_\infty)},\\ U_0^3=g\beta_f(T_w-T_\infty)\nu_f \end{array} \quad (10)$$

Using (10), Eqs. (2) – (5) can be converted into dimensionless form.

$$J_1\left[\frac{\partial u}{\partial t}-S\frac{\partial u}{\partial z}-Rv\right]=J_2\frac{\partial^2 u}{\partial z^2}+J_3\theta-M^*u \quad (11)$$

$$J_1\left[\frac{\partial v}{\partial t}-S\frac{\partial v}{\partial z}+Ru\right]=J_2\frac{\partial^2 v}{\partial z^2}-M^*v \quad (12)$$

$$J_4\Pr\left[\frac{\partial\theta}{\partial t}-S\frac{\partial\theta}{\partial z}\right]=\frac{k_{nf}}{k_f}\frac{\partial^2\theta}{\partial z^2}-\Pr Q_H\theta \quad (13)$$

$$Sc\left[\frac{\partial\psi}{\partial t}-S\frac{\partial\psi}{\partial z}\right]=\frac{\partial^2\psi}{\partial z^2}-ScKr\psi+ScSr\frac{\partial^2\theta}{\partial z^2} \quad (14)$$

The proposed boundary conditions for (6) & (7) composed as

$$u=0,\quad v=0,\quad \theta=0,\ \psi=0,\quad for\quad t\le 0 \quad (15)$$

$$\left.\begin{array}{l} u=\left[1+\dfrac{\varepsilon}{2}\left(e^{int}+e^{-int}\right)\right],\qquad v=0,\\ \theta'(0)=-\gamma\left[1-\theta(0)\right],\ \psi=1\ at\ z=0\\ u\to 0,\quad v\to 0,\quad \theta\to 0,\quad \psi\to 0\\ as\qquad z\to\infty \end{array}\right\} for\ t>0 \quad (16)$$

Eq. (17) is obtained from $H(z,t)=u(z,t)+iv(z,t)$;

$$J_1\left[\frac{\partial H}{\partial t}-S\frac{\partial H}{\partial z}+iRH\right]=J_2\frac{\partial^2 H}{\partial z^2}+J_3\theta-M^*H \quad (17)$$

The proposed boundary conditions (15) & (16) composed as

$$H=0,\theta=0,\psi=0,\quad for\quad t\le 0\ \&\quad any\ 'z' \quad (18)$$

$$\left.\begin{array}{l} H=\left[1+\dfrac{\varepsilon}{2}\left(e^{int}+e^{-int}\right)\right],\\ \theta'(0)=-\gamma\left[1-\theta(0)\right],\psi=1\ at\ z=0\\ H\to 0, v\to 0,\theta\to 0,\psi\to 0\\ as\qquad z\to\infty \end{array}\right\} for\ t>0 \quad (19)$$

III. TECHNIQUE METHODOLOGY

A short portrayal on the analytical methodology utilized for the arrangement of the above nonlinear, nondimensional, and coupled PDEs (17), (13) & (14) alongside the limit conditions (18) & (19) has been displayed in this segment, we assume that (see Ganapathi[12]).

$$H(z,t)=H_0(z,t)+\frac{\varepsilon}{2}\left[e^{int}H_1+e^{-int}H_2\right] \quad (20)$$

$$\theta(z,t) = \theta_0(z,t) + \frac{\varepsilon}{2}\left[e^{int}\,\theta_1 + e^{-int}\,\theta_2\right] \tag{21}$$

$$\psi(z,t) = \psi_0(z,t) + \frac{\varepsilon}{2}\left[e^{int}\,\psi_1 + e^{-int}\,\psi_2\right] \tag{22}$$

where $\varepsilon << 1$.

Substituting (20) – (22) into (17) with (13) & (14) gives in the following manner.

$$H(z,t) = (1-B_2)e^{-d_7 z} + B_2 e^{-d_1 z} + \frac{\varepsilon}{2}\left\{e^{-d_8 z}\, e^{\mathrm{int}} + e^{-d_9 z}\, e^{-\mathrm{int}}\right\} \tag{23}$$

$$\theta(z,t) = C_1 e^{-d_1 z} \tag{24}$$

$$\psi(z,t) = (1+B_1)e^{-d_4 z} - B_1 e^{-d_1 z} + \frac{\varepsilon}{2}\left\{d_8 e^{\mathrm{int}} + d_9 e^{-\mathrm{int}}\right\} \tag{25}$$

IV. RESULT ANALYSIS

A hypothetical report on the impact of nanoparticle Fe_3O_4 with nt = π/2, Pr = 6.785, ε = 0.01, K = 1, Kr = 1, M = 0.8, Q_H = 1, R = 1, γ = 1, Sr = 1 and S = 0.1 has been produced. The variety of velocity limit layer of the fluid field is indicates in fig.1. Because of the adjustment in the Soret number Sr curves with Sr = 1, 2, 3 and 4 individually. Contrasting the bends of the assumed figure; Observed that a developing Soret no., declines the velocity profiles. Figure 2 and 18 separately, mirrors the impact that the nano flow velocity & concentration profiles in support of various estimations of Sc. The impact of expanding estimations of Sc brings about a diminishing the flow velocity and concentration distributions. Also, the outcomes gives us an idea about that the importance of Sc is less articulated in occurrence of nano fluids seeing that contrasted to H_2O. Figures 3, 12 and 19 speaks to, the effect of S on the momentum, temperature & concentration distributions, separately. It tends to see that the momentum flow, temperature and concentration profiles decline with the expansion of the S. It is very obvious from the typical certainty to facilitate the suction stabilize the periphery growth. Clearly, results are obviously bolstered from the material perspective. The behavior of R on the nano momentum flow profiles for various estimations of Fe_3O_4 nano particle displays in figure 4. Distinguished that the nano momentum flow distribution across the limit layer diminishes with an expansion of R from the figure. From figs. 5, 13 and 20, the nano momentum flow, temperature & concentration distributions for various estimations of Q_H. There is a diminishing in the nano momentum flow and temperature distributions and increment in concentration dissemination in the company of an enhancing in Q_H from graphs. This happened because of the way that when temperature is assimilated, forces of buoyancy, declines which retard the fluid speed and in this manner offer ascent to an abatement in the momentum and temperature distributions. Figure 6, 14 and 21 represents the variation of Pr of nano fluids on momentum, temperature & concentration with ϕ = 0.15. The Pr of nano flows is found to diminish in momentum and temperature and increase in concentration with an enhancing of Prandtl number. Figure 7, 15 and 22, separately, delineates the impact of the nano particle ϕ on momentum, temperature & concentration distributions. Unmistakably as ϕ enhances, the nano momentum and temperature distributions enhances and concentration flow distribution diminishes. It concurs in the company of the material conduct that, when the volume portion of magnetite enhances, the conductivity enhances, and then boundary-layer thickness enhances.

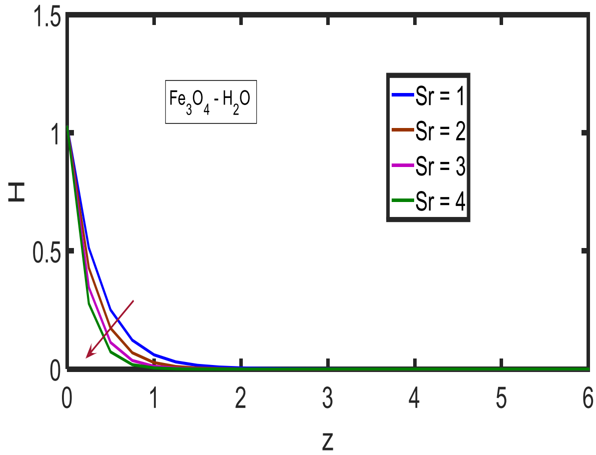

Fig. 1: Demonstrating the impact of So on H (z)

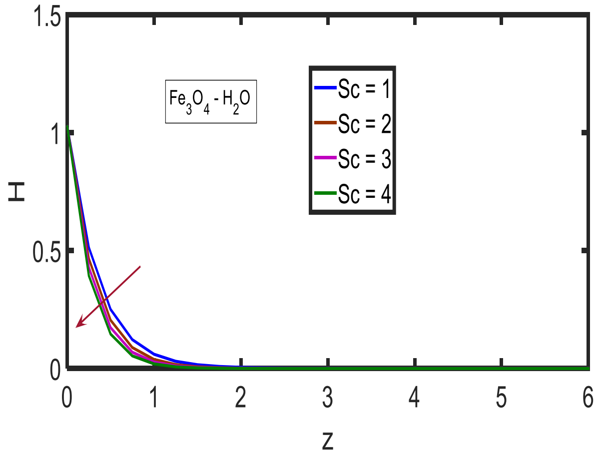

Fig. 2: Demonstrating Sc impacts on H (z)

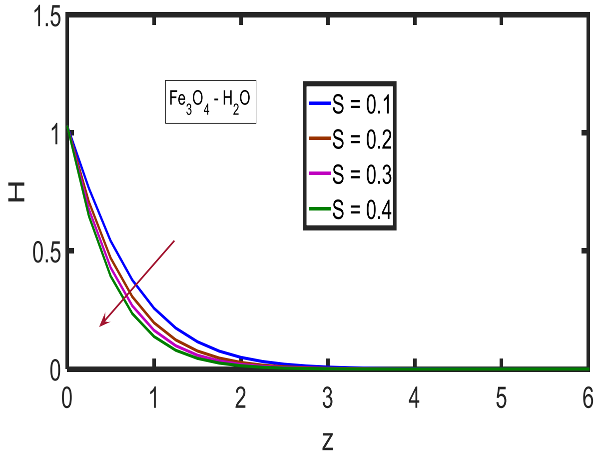

Fig. 3: Demonstrating S impacts on H (z)

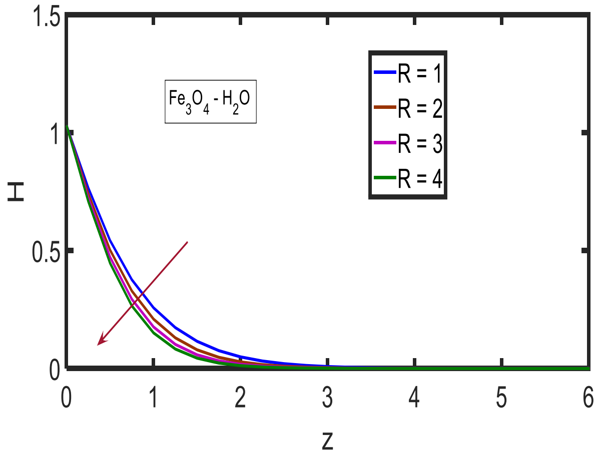

Fig. 4: Demonstrating R impacts on H (z)

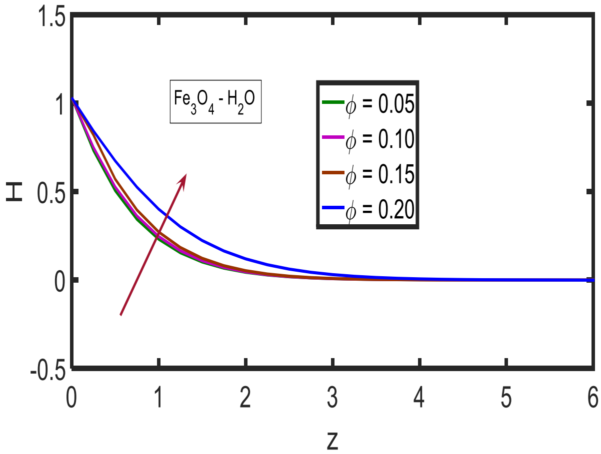

Fig. 7: Demonstrating ϕ impacts on H (z).

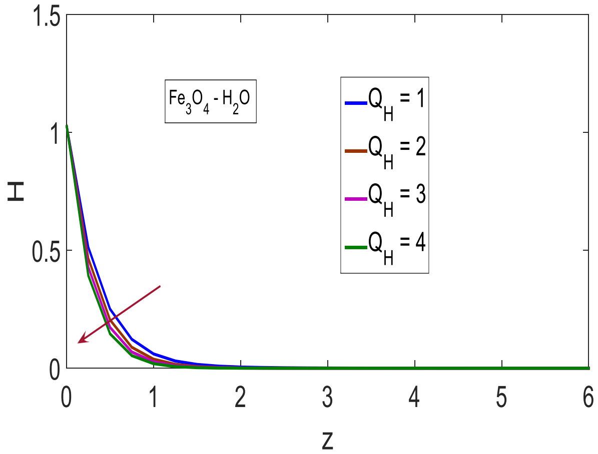

Fig. 5: Demonstrating Q_H impacts on H (z)

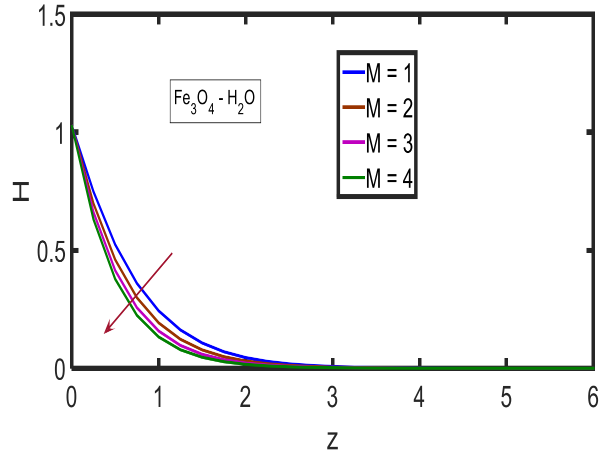

Fig. 8: Demonstrating M impacts on H (z)

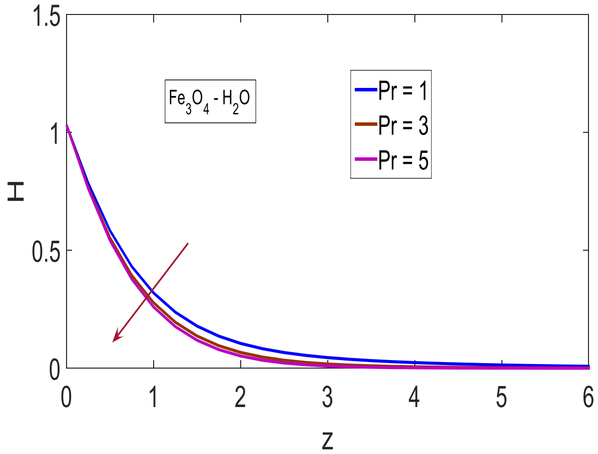

Fig. 6: Demonstrating Pr impacts on H (z)

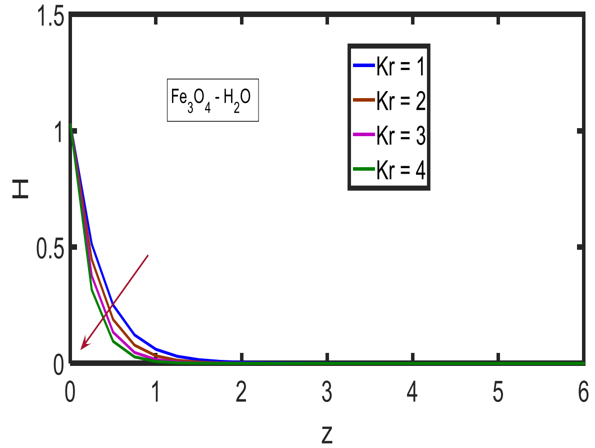

Fig. 9: Demonstrating Kr impacts on H (z)

Fig. 8 mirrors the conduct regular distribution for the nano flow momentum profiles for various estimations of M. Also, the nano flow fluid momentum of the fluid reduces with enhance in the quality of magnetic turf. Impacts of a transverse attractive field on an electrically leading flow offer ascent to force, is called the Lorentz force. The power tends to hinder the movement of the flow in the limit layer. The outcomes subjectively concur in the company of the desires, from the time when attractive field applies impeding power on the normal convective flow. The impact of the Kr on the nano flow momentum and concentration distributions, to Fe_3O_4 nano flow particles ($\phi \neq 0$) is outlined in Figures 9 and 23. An enhance in Kr bestows to the decline in the nano flow fluid momentum dispersion as well as increase in the nanofluid concentration dispersion noticed. Figure 10 hypothesis an influence of K on the nano flow fluid momentum dispersion. Obviously as K increases, the nano flow fluid velocity also enhances. Figures 11, 16 and 24, exhibits an influence of γ, flow velocity, temperature & concentration. As a yield of figures, it is seen that the momentum and temperature enhances and in the concentration it occurred in reverse.

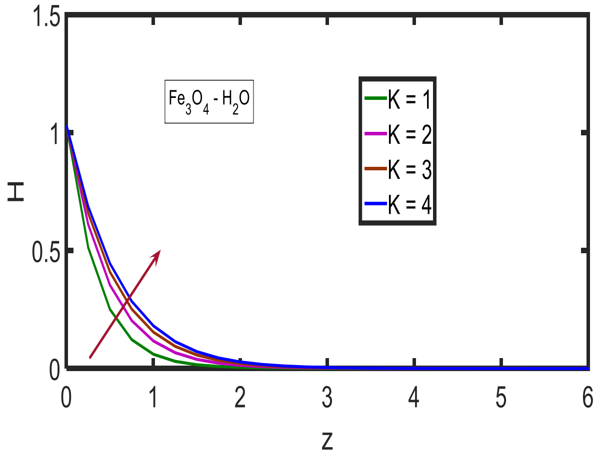

Fig. 10: Demonstrating K impacts on H (z).

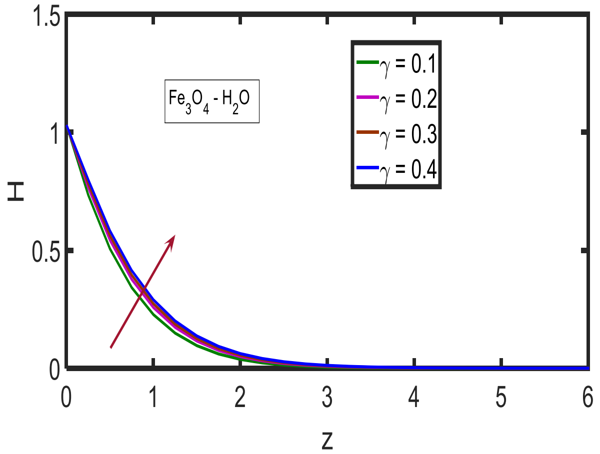

Fig. 11: Demonstrating γ impacts on H (z)

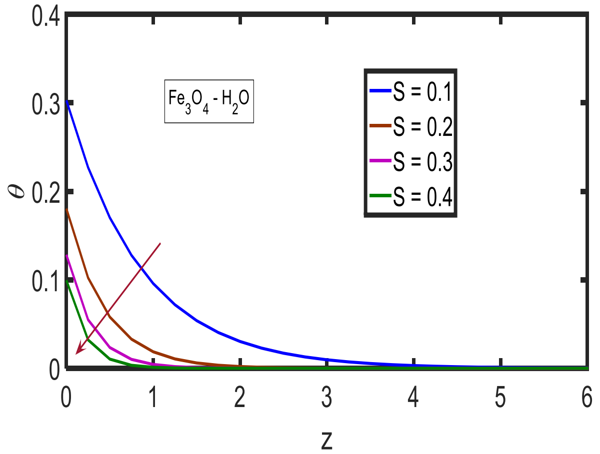

Fig. 12: Demonstrating S impacts on θ (z)

From the temperature dissemination we have, the fluid inside the thermal boundary layer increments in the company of enhancing values of γ. It is very obvious from fig.17, impact of soret number Sr on concentration for Fe_3O_4 nanoparticles with $\phi = 0.15$(nanofluid). As a yield of figure, it is justifiable to the concentration of the fluid transversely the momentum limit layer diminishes by increasing soret number Sr.

V. CONCLUSIONS

The present examination, we considered hypothetically

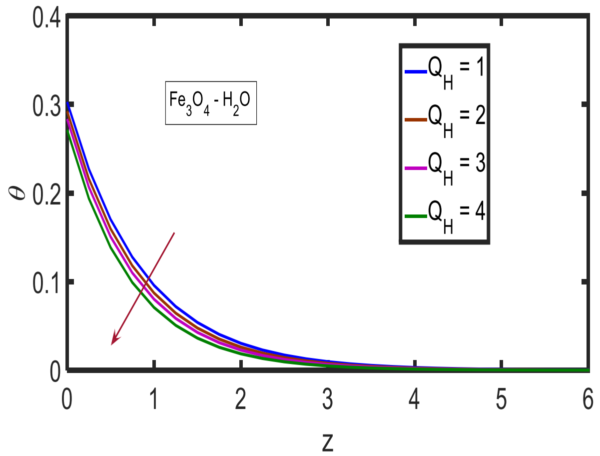

Fig. 13: Demonstrating Q_H impacts on θ (z).

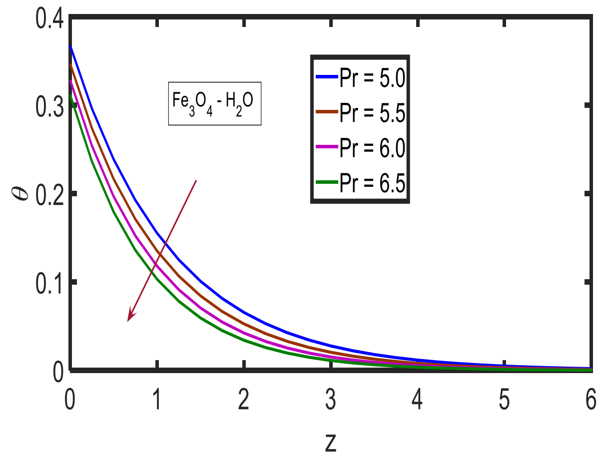

Fig. 14: Demonstrating Pr impacts on θ (z)

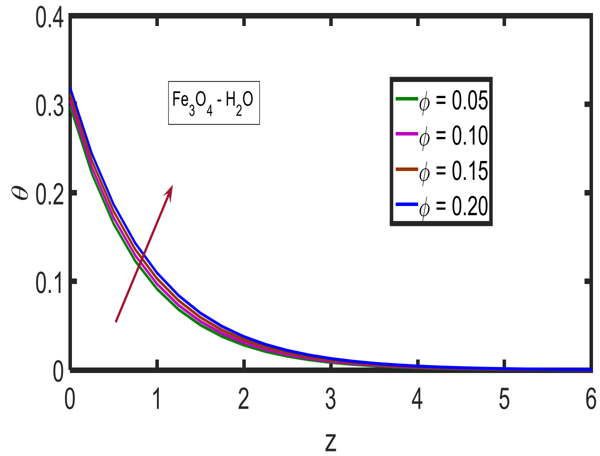

Fig. 15: Demonstrating ϕ impacts on θ (z)

the influences of the harsh Magnetite or ferrous ferric oxide nano particles happening the transient magneto convective flow fluid of an incompressible flow is intended to explained. Problem was designed the way in which the momentum, temperature & concentration; just as the skin friction, the heat flux and Sherwood number rely on the nano particle volume fraction parameter. In boundary layer locale, the flow velocity reduces with an enhance in Sr, Sc, R, M, S, Pr, Kr and Q_H but effect is reverse for nanoparticle

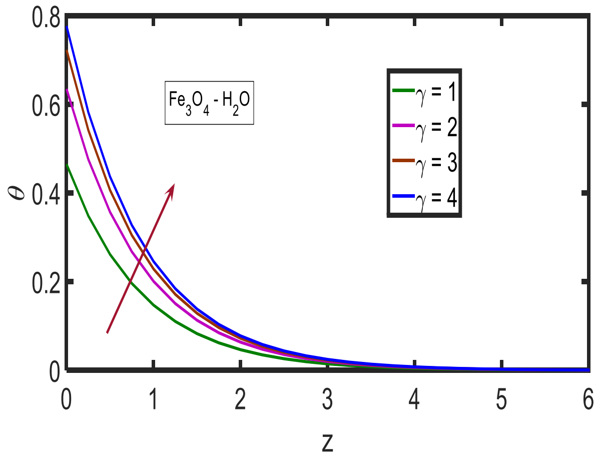

Fig. 16: Demonstrating γ impacts on θ (z).

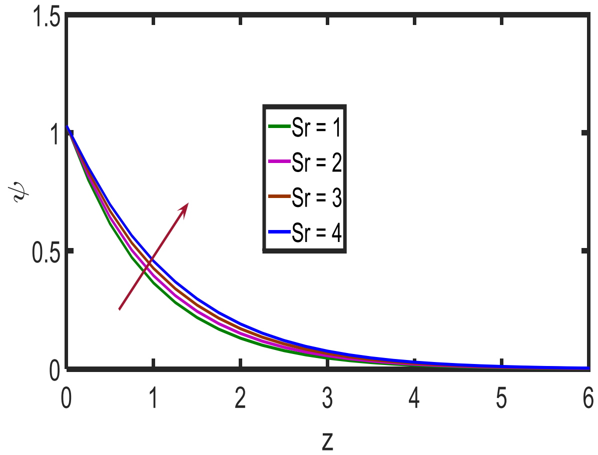

Fig. 17: Demonstrating Sr impacts on ψ (z)

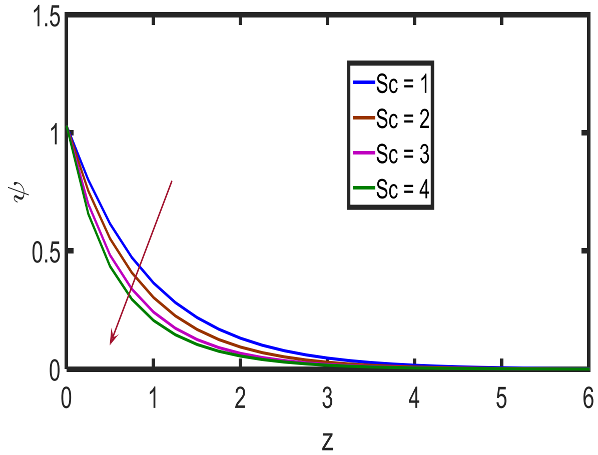

Fig. 18: Demonstrating Sc impacts on ψ (z)

volume fraction ϕ, convective parameter γ and K. An enlarge in γ and ϕ leads to enhance the thermal limit layer thickness however inverse impact happens for S, Pr and Q_H.

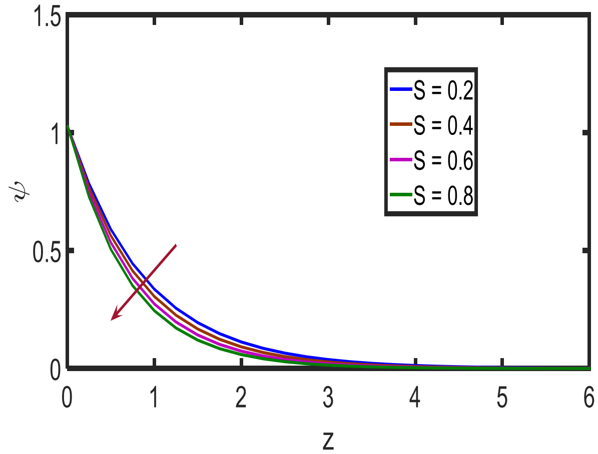

Fig. 19: Demonstrating S impacts on ψ (z).

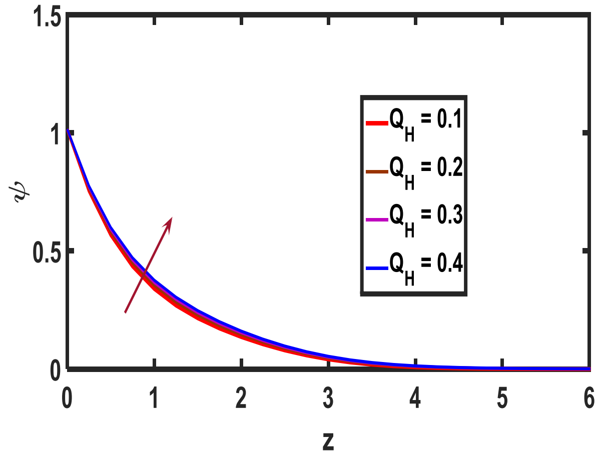

Fig. 20: Demonstrating Q_H impacts on ψ (z)

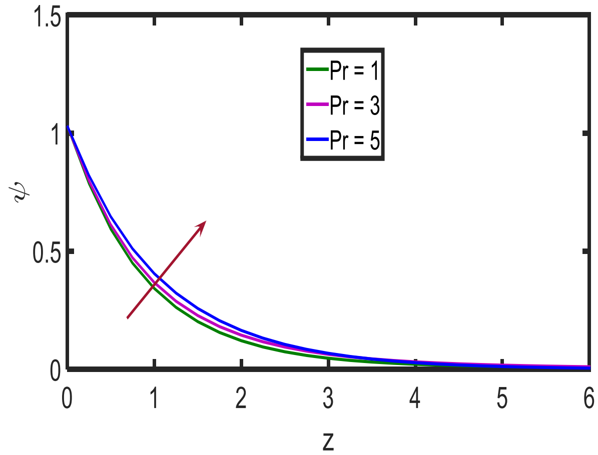

Fig. 21: Demonstrating Pr impacts on ψ (z)

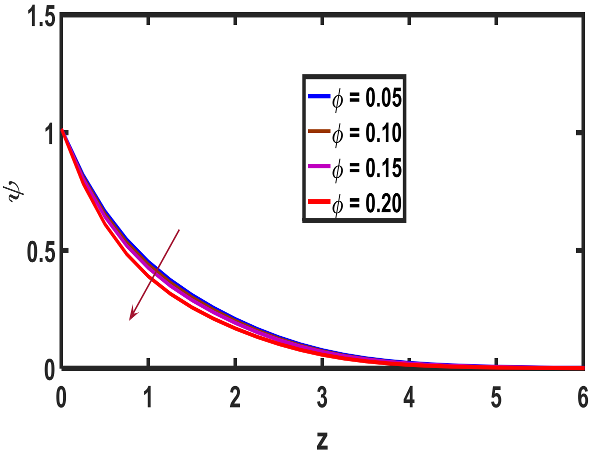

Fig. 22: Demonstrating ϕ impacts on ψ (z).

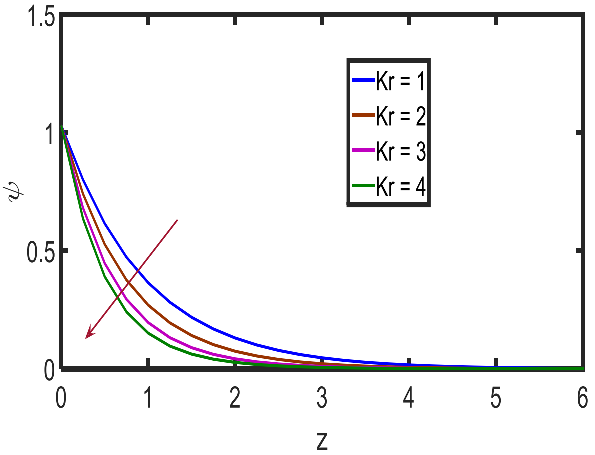

Fig. 23: Demonstrating Kr impacts on ψ (z)

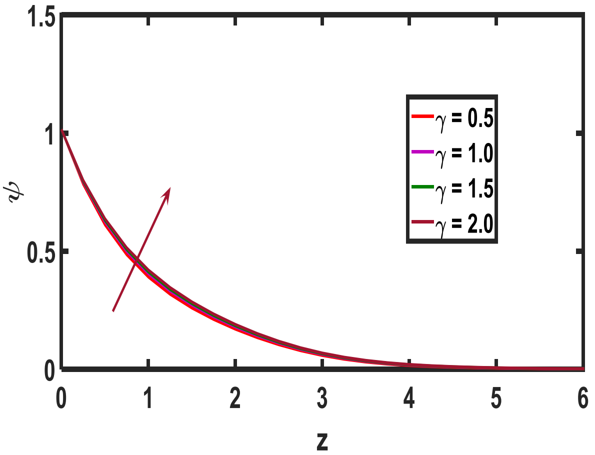

Fig. 24: Demonstrating γ impacts on ψ (z).

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