JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 1, 2022, p. 990 - 998
https://publishoa.com
ISSN: 1309-3452

Heat and Mass transfer Flow on Magneto Hydro Dynamic Convective flow through Porous medium between Infinite vertical plate with Soret and Joules dissipation

B. Lakshamanna [1], A. Shareef[2] , S. Venkateswarlu [4]

[1] Dept. of Mathematics, St.Joseph's Degree college, Sunkesula road Kurnool, A.P, India.
[2] Dept. of Mathematics, Ashoka women's engineering college,Kurnool, A.P, India
[3] Dept. of Mathematics, RGM College of Engineering and Technology, Nandyal, Kurnool, AP, India

ABSTRACT
In the present paper, we have deliberated the combined impact of magneto hydro dynamic mixed convective two dimensional flow of viscous fluid which is of electrically conducting and incompressible through porous medium past between unbounded vertical plate taking Soret and Joules dissipations into account The dimensionless equations are examined by using perturbation technique. The impacts of the dimensionless parameters, warmth, velocity and concentration distributions are examined with the aids of graphs .Also the consequences of the pertinent parameters at the skin-friction coefficient and rates of heat and mass transfer in phrases of the Nusselt and Sherwood numbers are computationally discussed. .

Keywords: Vertical plate, porous medium, heat and mass transfer, Soret and Joules dissipations, magnetic field, skin-friction, Nusselt number, Sherwood numbers.

1. Introduction

MHD is presently bear a phase of great growth and differentiation of subject matter. The attention at the present problem achieve by their importance in liquid materials, electrolytes and ionized gases. with their varied importance, these type of flows have been examined by various persons among them are Raju and Varma [1], Srinivas and Muthuraj [2] and Orthan and Ahmet [3]. Reddy et al. [4] examined Thermo-diffusion and chemical effects by concurrent thermal and mass diffusion in Magneto Hydro Dynamic mixed convection flow by holmic warming. Magneto Hydro Dynamic mixed convection by Soret and Dufour impacts over permeable channel was studied by Makinde [5]. The considerable focus of our discussion is the impact on mixed convection flow of the extension of a second fluid. The consequence of Soret impact on the flow of an electrically conducting fluid past on a vertical plate in the existence of varied physical parameters has been examined by Satya Narayana et al. [6]. Veera Krishna et al. [6-10] discussed some MHD flows through porous channels. Motivated from, the above studies In the current paper, we have deliberate the joint effects of Magneto Hydro Dynamic mixed convective multi dimensional flow of an incompressible viscous fluid of electrically conducting fluid through porous medium an unbounded vertical plate taking Soret and Joules dissipations into account.

2. Formulation and Solution of the Problem

We take the joint convention flow of viscous fluid which is of electrically conducting and incompressible. The x- axis is considered as upward direction parallel to the plate and z- axis is perpendicular to the plate as shown in the figure 1. A uniform magnetic field is applied, along the direction normal to X-axis. All the substantial variables are independent of the variable x because the movement is 2 dimensional, plate length is unbounded. Between the fluid and species a first order homogeneous chemical reaction is taken in to account, it says the species concentration is directly proportional to the rate of chemical reaction .For the continuity, momentum, energy and mass for a flow of an electrically conducting viscous fluid the governing equations are taken as

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 1, 2022, p. 990 - 998
https://publishoa.com
ISSN: 1309-3452

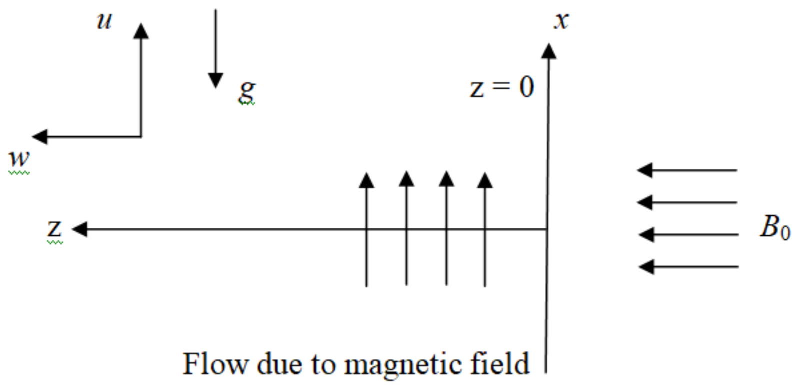

Fig.1: Physical Configuration of the Problem

$$\frac{\partial w}{\partial z} = o \Rightarrow -w_0 \quad (w_0 \geq) \tag{1}$$

$$w\frac{\partial u}{\partial v} = v\frac{\partial^2 u}{\partial z^2} - \frac{\sigma B_0^2}{\rho}u - \frac{v}{k}u + g\beta(T - T_\infty) + g\beta^*(C - C_\infty) \tag{2}$$

$$w\frac{\partial w}{\partial z} = v\frac{\partial^2 w}{\partial z^2} - \frac{\sigma B_0^2}{\rho}w - \frac{v}{k}w \tag{3}$$

$$w\frac{dT}{dz} = \frac{k_1}{\rho C_p}\frac{d^2 T}{dz^2} + \frac{v}{C_p}\left(\frac{du}{dz}\right)^2 + \frac{\sigma B_0^2}{\rho C_p}(u^2 + w^2) + \frac{Q_0}{\rho C_p}(T - T_\infty) \tag{4}$$

$$w\frac{dC}{dz} = D\frac{d^2 C}{dz^2} + D_1\frac{d^2 T}{dz^2} - k_2(C - C_\infty) \tag{5}$$

The boundary conditions for the velocity, temperature and concentration fields are

$$u = 0;\ w = 0 \quad T = T_W \quad C = C_W \ \ at\ z = 0$$

$$u = (0);\ w = (0); \quad T \to T_\infty; \quad C \to C_\infty\ at \quad z \to \infty \tag{6}$$

Combining equations (2) and (3), let $q = u + iw$ we obtain

$$w\frac{\partial q}{\partial v}=\nu\frac{\partial^2 q}{\partial z^2}-\frac{\sigma B_0^2}{\rho}q-\frac{\nu}{k}q+g\beta(T-T_\infty)+g\beta^*(C-C_\infty)$$

(7)

Introducing following non-dimensional quantities

$$y=\frac{y^* v_0}{\upsilon},\ u=\frac{u^*}{v_0},\ \Pr=\frac{\upsilon\rho C_p}{k},\ \theta=\frac{T^*-T_\infty}{T_w-T_\infty},\ \phi=\frac{C^*-C_\infty}{C_w-C_\infty},\ \mathrm{Gr}=\frac{\nu g\beta(\mathrm{T}_w-\mathrm{T}_\infty)}{v_0^3},$$

$$\mathrm{Gm}=\frac{\nu g\beta^*(C_w-C_\infty)}{v_0^3},Ec=\frac{v_0^2}{C_p(T_w-T_\infty)},\ M^2=\frac{\sigma B_0^2\upsilon}{\rho v_0^2},\ \mathrm{K}=\frac{\nu}{kv_0^2},\ \nu=\frac{\mu}{\rho},$$

$$\mathrm{Sc}=\frac{\nu}{D},\ So=\frac{\mathrm{D}_1(\mathrm{T}_w-\mathrm{T}_\infty)}{\nu(C_w-C_\infty)},\ Kr=\frac{\nu k_1}{v_0^2},\ Q=\frac{Q_o\nu}{\rho C_p v_0^2}. \qquad (8)$$

Here Gr is the Grashf number, Gm is the mass of Grashof number, Pr *is the* Pr *andtl numbwer Sc is the Schmidt number, So is the Soret number, Ec is the Eckret number, M is the magnet parameter, K is the permeability parameter, Kr is the chemical reaction parameter.*

For the equations form (2) - (4), the non dimensional form of governing equations are

$$q''+q'-\left(M^2+\frac{1}{\mathrm{K}}\right)u=-\mathrm{Gr}\theta-\mathrm{Gm}\phi \qquad (9)$$

$$\theta''+\Pr\theta'+\Pr Ec(u')^2+\Pr EcM^2(u^2+w^2)+\Pr Q\theta=0 \qquad (10)$$

$$\phi''+\mathrm{Sc}\phi'-\mathrm{Sc}Kr\phi+So\mathrm{Sc}\theta''=0 \qquad (11)$$

The corresponding boundary conditions in dimensionless form are reduced to

$$\begin{aligned}&q=0;\quad \theta=1;\quad \phi=1 \quad \text{at } z=0\\ &q\to 0;\ \theta\to 0;\ \phi\to 0 \quad \text{at } \mathrm{z}\to\infty\end{aligned} \qquad (12)$$

In the index of the Eckert number Ec the substantial variables q, θ and ϕ are to be expanded. It is substantially hold as Ec is always less the unity for the incompressible fluid flow. The joules dissipation is overlying on the original fluid flow so this is to be disrupted substantially . Hence we consider

$$\left.\begin{aligned} q(y) &= q_0(y) + Ecq_1(y) + O\left(Ec^2\right) \\ \theta(y) &= \theta_0(y) + Ec\theta_1(y) + O\left(Ec^2\right) \\ \phi(y) &= \phi_0(y) + Ec\phi_1(y) + O\left(Ec^2\right) \end{aligned}\right\} \tag{13}$$

Substituting equation (13) into equations (9)-(11) .by comparing the Ec coefficients of equal powers ,to get the zeros order, first order differential equations and boundary conditions.

Solving these equations, we obtain temperature, concentration and velocity distribution in the boundary layer.

Skin function, Nusselt number and Sherwood number:

The non-dimensional Skin friction coefficient at the plate, the rate of heat transfer in terms Nusselt number and Sherwood number are given by

$$C_f = \left(\frac{\partial u}{\partial z}\right)_{z=0}, \qquad Nu = \left(\frac{\partial \theta}{\partial z}\right)_{z=0}, \qquad Sh = \left(\frac{\partial \phi}{\partial z}\right)_{z=0}$$

3. Results and Discussion

From the Fig.2, we observer by incresing the intencity of the magnetic field M, the signifecnce of the velocity segments u and v decreases.it is because of the This is due to the evidence that the initiation of a translation magnetic field, perpendicular to the direction of the fluid flow, it has habitually generate the drag known's like Lorentz force it resist the fluid flow. The response velocity is going to decrease by increasing Hartmann number *M*.Fig.3, it is observed by increasing the permeability parameter K the significance the velocity segments *u* and *w* growing up. It is observed The permeability perameter decrease the fluid flow velocity through out the fluid region. The consequent velocity is also increases with enhancing permeability perameter *K*.

In Fig.4 it is showing that the impacts of Grashf number Gr over the velocity elements *u* and *w* for the constant values of another parameters. And is noticed that non dimensional velocity grown up with it is observed that the dimensionless velocity increases with rising Grashf number Gr. In Fig.5it is shown that the effects of heat generating parameter Q over the non dimensional velocity elements *u* and *w* for the constant values of the parameters. It is observer that the two non dimensional velocity elements u and v rising together with Q. In Fig 6 we study the influence of the pradntl number P*r* over the non dimensional warmth to the constant values of another parameters. The warmth decreases by rising Prandtl number P*r*. Fig.7 shows the consequence of the non- dimensional absorption to different values of parameter Kc (chemical reaction). This is noticeable when raising the value of Kc the decrease is to be noticed in the concentration profiles. It indicates that buoyancy impacts are considerable over the plate. From the tables 1 to 3 we observe the change in skin friction parameter, the amount of heat exchange (Nusselt number) and the amount of mass transmission (Sherwood number) to the different parameters of interest. We seen that the Skin friction coefficient decreases by enhancing Reaction coefficient Kc, Pr (Prandtl number),M (Hartmann number) and Sc (Schmidt number); same as it increases permeability coefficient K, thermal coefficient ,Gr (Grashof number), Gm(mass Grashof number),Q (Heat generation parameter) and So (Soret parameter (showed in table 1).

The significance of the Nusselt number (Nu) enhances by rising Prandtl number (Pr) and reduces by enhancing Heat generation parameter coefficient (*Q)* (showed in table 2). Likewise the significant of the Sherwood parameter (Sh) enhances by rising Schmidt parameter(Sc) or Reaction Parameter (Kc) and decreases by enhancing Soret number(*So)*. For the effectiveness of our effort, in the absence of heat source and porous medium we compare our results with the we have compared our results with the actual outcomes of Reddy et al. [4]. Our result shows to be in excellent agreement with the existing results (see Table .4).

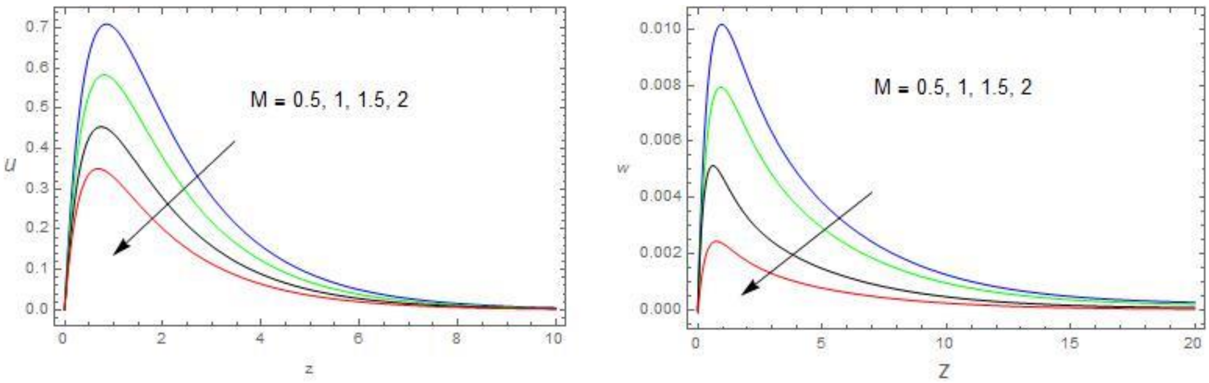

Fig 2. The velocity profiles for *u* and *w* against *M*

K=0.5,Pr=0.71,Gr=3,Gm=1,Q=0.1,Kc=1,Sc=0.22,So = 0.5

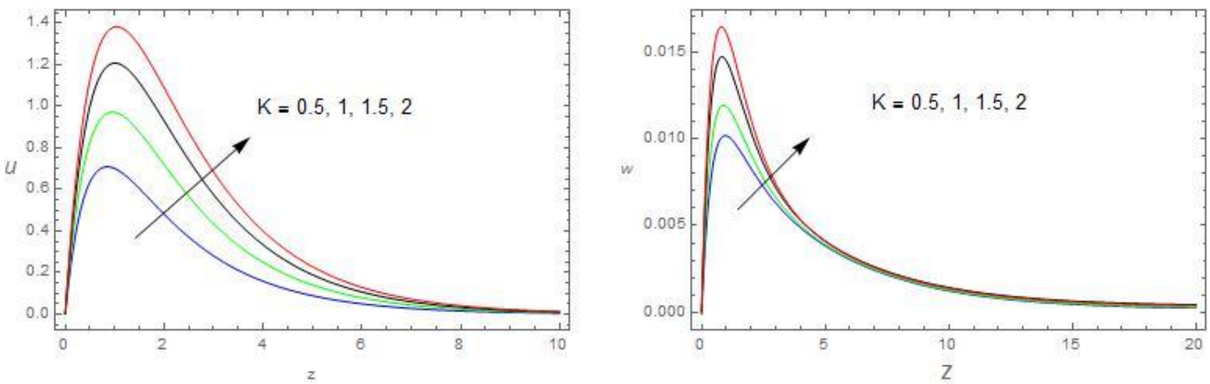

Fig 3. The velocity profiles for *u* and *w* against *K*

M = 0.5, Pr = 0.71, Gr = 3,Gm = 1,Q = 0.1, Kc = 1, Sc = 0.22,So = 0.5

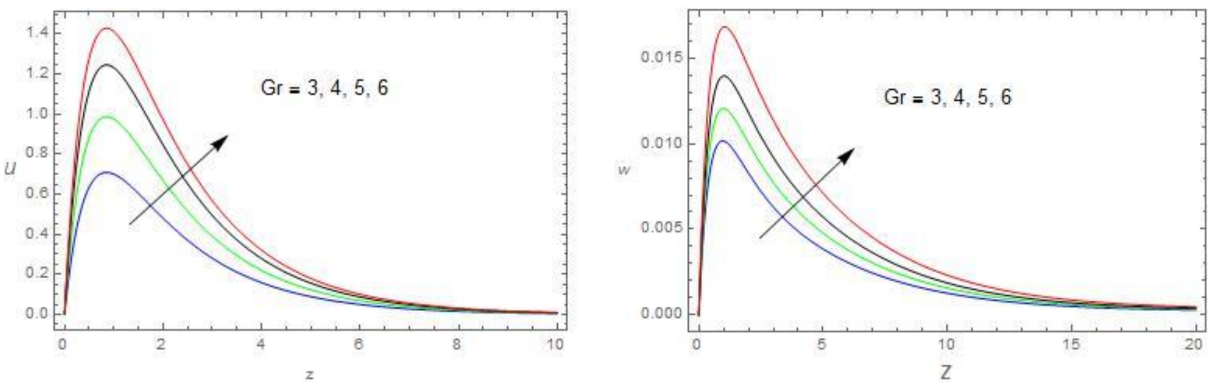

Fig 4 .The velocity profiles for *u* and *w* against Gr

$M = 0.5, K = 0.5, \mathrm{Pr} = 0.71, \mathrm{Gm} = 1, Q = 0.1, \mathrm{Kc} = 1, \mathrm{Sc} = 0.22, So = 0.5$

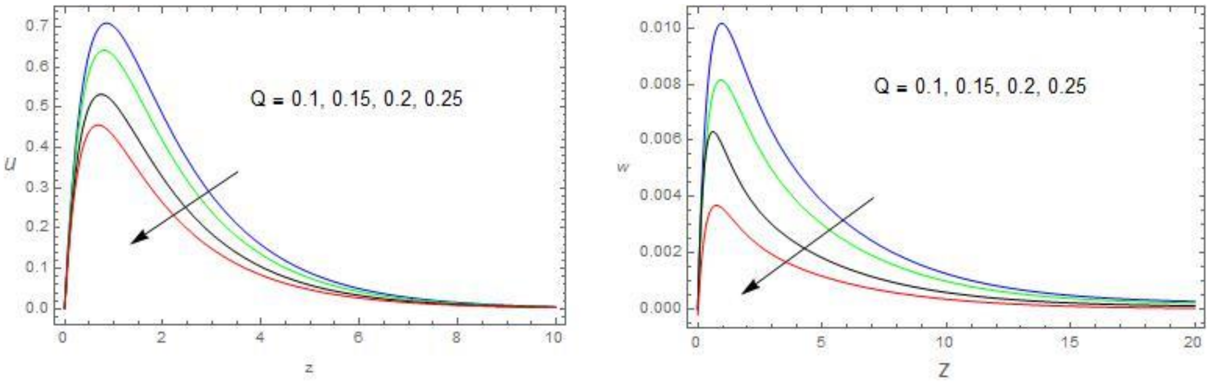

Fig 5. The velocity profiles for *u* and *w* against *Q*

$M=0.5, K=0.5, \mathrm{Pr}=0.71, \mathrm{Gr}=3, \mathrm{Gm}=1, \mathrm{Kc}=1, \mathrm{Sc}=0.22, So=0.5$

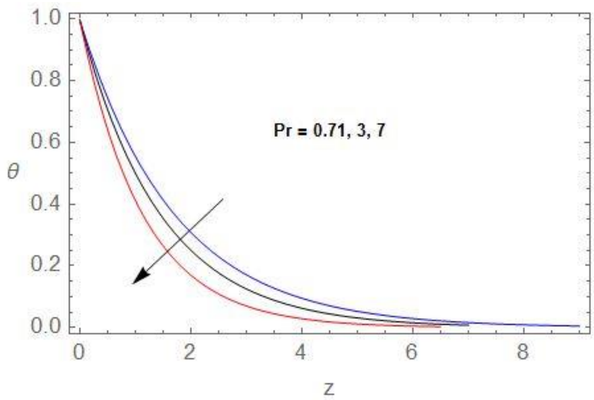

Fig 6. The temperature profile for θ against Pr with Q = 0.1

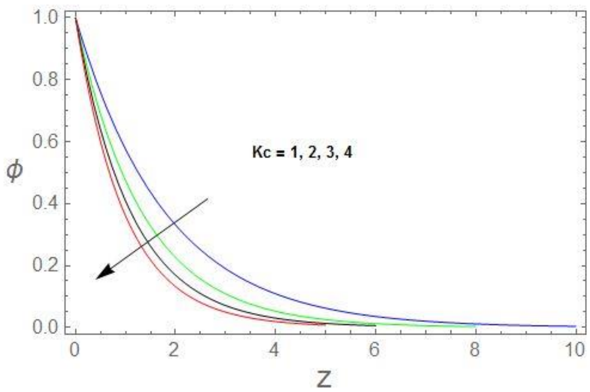

Fig 7. The Concentration profile for ϕ against Kc with *So* = 0.5, Sc = 0.22

Table 1. Shear stress $(Ec = 0.01)$

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 1, 2022, p. 990 - 998
https://publishoa.com
ISSN: 1309-3452

M	*K*	Pr	Gr	Gm	Kc	*Q*	Sc	*So*	$\lvert\tau\rvert$
0.5	0.5	0.71	3	1	1	0.1	0.22	0.5	2.41279
1									2.10318
1.5									1.82170
	1								3.08254
	1.5								3.47849
		3							1.39572
		7							1.02851
			4						3.01694
			5						3.62411
				2					3.02759
				3					3.64290
					2				2.34754
					3				2.30599
						0.5			2.68722
						0.8			2.81238
							0.3		2.37349
							0.6		2.27696
								1	2.42702
								1.5	2.44124

Table 2. Nusselt number

$(M=0.5, K=0.5, \mathrm{Gr}=3, \mathrm{Gm}=1, \mathrm{Kc}=1, So=0.5, \mathrm{Sc}=0.22, Ec=0.01)$

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 1, 2022, p. 990 - 998
https://publishoa.com
ISSN: 1309-3452

Pr	*Q*	Nu
0.71	0.1	-0.579521
3		-3.009720
7		-6.910550
	0.2	-0.342134
	0.3	-0.133423

Table 3. Sherwood number

$(M=0.5, K=0.5, \mathrm{Pr}=0.71, \mathrm{Gr}=3, \mathrm{Gm}=1, Q=0.1, \mathrm{Kc}=1, Ec=0.01)$

So	Sc	Kc	Sh
0.5	0.22	1	-0.553031
1			-0.514333
1.5			-0.475675
	0.3		-0.667466
	0.6		-1.033987
		2	-0.750102
		3	-0.901226

Table 4. Comparison of results with Reddy et al. [25]

for $(K=\infty, \mathrm{Gr}=3, \mathrm{Gm}=1, \mathrm{Pr}=0.71, Q=0, Ec=0.01)$

M	***Kc***	***So***	***Sc***	***Reddy et al. [25]***			***Present work***		
				Cf	***Nu***	***Sh***	***Cf***	***Nu***	***Sh***
0.5	1	0.5	0.22	4.70415	-0.65747	-0.54588	4.70417	-0.65742	-0.54587
1				3.15452	-0.68073	-0.54341	3.15455	-0.68077	-0.54344
1.5				2.30347	-0.69218	-0.54326	2.30346	-0.69216	-0.54328
	2			4.41999	-0.66541	-0.74314	4.41997	-0.66540	-0.74313
	3			4.26892	-0.66922	-0.89451	4.26891	-0.66925	-0.89457

		1		4.77844	-0.65518	-0.50049	4.77841	-0.65516	-0.50042
		1.5		4.85268	-0.65281	-0.45540	4.85266	-0.65284	-0.45544
			0.3	4.52842	-0.66246	-0.65738	4.5285	-0.66245	-0.65739
			0.6	4.19354	-0.67098	-1.01922	4.19356	-0.67099	-1.01921

4. Conclusions

1. When enhancing the Hartmann number, the resultant velocity reduces.
2. By enhancing the heat source parameter the velocity and non dimensional temperature rises.
3. By enhancing the magnetic field parameter or permeability parameter the Sc (skin friction coefficient) reduces, this indicates the opposite effect the the case of Grashof (Gm)and mass grashof (Gr) numbers.
4. By enhancing the Prandtl number the Nusselt number rises.

References

[1]. MC. Raju, SVK. Varma , Unsteady MHD free convection oscillatory Couette flow through a porous medium with periodic wall temperature. J Fut Eng. Technol, 6(4) (2011), 7–12.

[2]. . S .Srinivas, R. Muthuraj, MHD flow with slip effects and temperature-dependent heat source in a vertical wavy porous space. Chem Eng Commun, 197(11) (2010), 1387–403.

[3]. A .Orthan, K. Ahmet , MHD mixed convective heat transfer flow about an inclined plate. Int J Heat Mass Transfer, 46(2009), 129–36.

[4]. N Reddy Anada, SVK .Varma, MC. Raju, Thermo-diffusion and chemical effects with simultaneous thermal and mass diffusion in MHD mixed convection flow with ohmic heating. J Naval Architect Mar Eng. 6: (2009), pp. 84-3

[5]. OD. Makinde , On MHD mixed convection with Soret and Dufour effects past a vertical plate embedded in a porous medium. Latin Am Appl Res (2011); 41:63–8.

[6]. PV. Satya Narayana, CS. Sravanthi, Simultaneous effects of Soret and ohmic heating on MHD free convective heat and mass transfer flow of micropolar fluid with porous medium, Elixir Appl Math 2012; 48:9379–86.

[7]. M .VeeraKrishna., G.Subba Reddy, Unsteady MHD convective flow of Second grade fluid through a porous medium in a Rotating parallel plate channel with temperature dependent source, IOP Conf. Series: Materials Science and Engineering, vol. 149.(2016), p. 012216, DOI: 10.1088/1757-899X/149/1/012216.

[8]. M.Veera Krishna, G.Subba Reddy, A.J.Chamkha, Hall effects on unsteady MHD oscillatory free convective flow of second grade fluid through porous medium between two vertical plates, Physics of Fluids, vol. 30, 023106(2018), DOI: 10.1063/1.5010863.

[9]. M. Veera Krishna, A.J Chamkha, Hall effects on unsteady MHD flow of second grade fluid through porous medium with ramped wall temperature and ramped surface concentration, Physics of Fluids 30, 053101(2018), DOI: https://doi.org/10.1063/1.5025542.

[10]. M. Veera Krishna, M .Gangadhara Reddy, A.J. Chamkha, Heat and mass transfer on MHD free convective flow over an infinite non- conducting vertical flat porous plate, Int. Jour. of Fluid Mech. Res., 45(5) (2019), pp. 1-25, DOI: 10.1615/InterJFluidMechRes.2018025004.