MHD Free Convection Warm and Mass Transport In Permeable Plate

Hoshiyar Singh , Yogesh Khandelwal, Ranveer Singh, Nitin Chouhan, N.C. Jain

Abstract: This exploration look at in the present paper that contemplated radiation consequences for the transient liberate transmission and profusion exchange stream of an energetic directing, thick, compact fluid, through a vast erect permeable medium, in nearness of consistent remotely connected transverse attractive field. Also, at the plate there is slip for speed field. Receiving a perturbative arrangement development about a little parameter, articulation are gotten and are indicated graphically portraying the speed, temperature, skin-contact coefficient and the pace of warmth move.

Index Terms: Free transmission, Incompressible ,MHD Radiation ,Vertical permeable plate.

I. INTRODUCTION

It is extremely required to learn the gratis transmission stream during non-homogeneous permeable intermediate and to guess its result on warm and mass transport. Raptis and Kafousias [5] are a few of the people to learn the dissimilar troubles during permeable intermediate. Khandelwal et al. [3] comprise considered MHD stream troubles during erratic permeable intermediate. Effects of emission on the liberated convection stream during permeable intermediate having changeable permeability and slanting mesmeric field was presented by Maharshi and Tak [4]. Jothimani et al. [2] have studied unsteady free convection during a permeable intermediate of changeable permeability enclosed by permeable erect plate with stable warm and mass fluctuation. This research examine the terminations of slip variables, magnetic region with emission on free spread, mass exchange complications during permeable plate of irregular absorbent permeability. It is examined that increasing Prandt number

increases rate of warm transport but decrease skin confrontation.

Revised Manuscript Received on October 30, 2019.
* Correspondence Author
Hoshiyar Singh*, Department of Mathematics, Jaipur National University , Jaipur, Rajasthan. India. Email: hskg@rediffmail.com , hoshiyar@jnujaipur.ac.in
Yogesh Khandelwal, Department of Mathematics, Jaipur National University , Jaipur,Rajasthan. India. Email: yogesh@jnujaipur.ac.in
Ranveer Singh,Department of Machenical Engineering , Jaipur National University , Jaipur, Rajasthan. India. Email: duduraj@gmail.com
Nitin Chouhan, Department of Mathematics, Jaipur National University , Jaipur,Rajasthan. India. Email: nitinchouhan007@gmail.com
N.C. Jain ,Department of Mathematics, University of rajasthan , India. Email: jainnc181@rediffmail.com

II. MATHEMATICAL GROUPING OF THE DIFFICULTY AND SOLUTION

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

$$\frac{\partial u}{\partial t} + v\frac{\partial u}{\partial y} = g\beta(T - T_\infty) + g\beta^*(C - C_\infty) + \nu\left(\frac{\partial^2 u}{\partial y^2}\right) - \frac{\nu u}{K(t)} - \frac{\sigma B_0^2 u}{\rho} \tag{2}$$

$$\frac{\partial T}{\partial t} + v\frac{\partial T}{\partial y} = \frac{k}{\rho C_p}\left(\frac{\partial^2 T}{\partial y^2}\right) - \frac{1}{\rho C_p}\frac{dq_r}{dy} \tag{3}$$

$$\frac{\partial C}{\partial t} + v\frac{\partial C}{\partial y} = D\frac{\partial^2 C}{\partial y^2} \tag{4}$$

Where

$$K(t) = K_0(1 + \in A\, e^{-nt}) \tag{5}$$

q_r is written (Cogley et. al [1])as:

$$\frac{\partial q_r}{\partial y} = 4(T - T_\infty)I \tag{6}$$

Where

$$I = \int_0^\infty K_{\lambda n}\frac{\partial e_{b\lambda}}{\partial T}d\lambda,$$

Corresponding border states as follows:

$$\left.\begin{array}{llll} u = U_0(1+\in e^{-nt}) + L_1\frac{\partial u}{\partial y}, & \frac{\partial T}{\partial y} = -\frac{q}{k}, & \frac{\partial C}{\partial y} = -\frac{m}{D} & \text{at } y = 0 \\ u = 0, & T \to T_\infty, & C \to C_\infty & \text{at } y \to \infty \end{array}\right\} \tag{7}$$

Integrate the Eq.(1) for variable's pressure level provide

$$v = -v_0(1 + \in B\, e^{-nt}) \tag{8}$$

Here B is actual affirmative persistent and $\in$ is tiny just as $\in$ B <<< 1.

We initiate succeeding dimensionless substantial's

$$y^* = \frac{y v_0}{\nu},\ t^* = \frac{v_0^2 t}{4\nu},\ n^* = \frac{4\nu n}{v_0^2},\ C = \frac{D v_0 (C - C_\infty)}{\nu m},$$

$$u^* = \frac{u}{v_0}, \quad \theta = \frac{kv_0(T - T_\infty)}{\nu q}, \quad M^2 = \frac{\sigma B_0^2 \nu}{\rho v_0^2},$$

$$Gr = \frac{\nu^2 g\beta q}{k v_0^4}, \quad Gc = \frac{g\beta^* \nu^2 m}{D v_0^4}, \quad K_0^* = \frac{K_0 v_0^2}{\nu^2},$$

$$Pr = \frac{\mu C_p}{k}, \quad S = \frac{4\nu I}{\rho C_p v_0^2}, \quad Sc = \frac{\nu}{D}, \quad h_1 = \frac{L_1 v_0}{\nu}, \alpha = \frac{U_0}{v_0}$$

Eq.(2), (3) and (4) diminish to the succeeding formation after drizzling the star-shaped character above them:

$$\frac{1}{4}\frac{\partial u}{\partial t} - (1 + \in B e^{-nt})\frac{\partial u}{\partial y} = Gr\,\theta + Gc\,C + \frac{\partial^2 u}{\partial y^2} - \left(M^2 + \frac{1}{K_0(1 + \in A e^{-nt})}\right)u \tag{9}$$

$$\frac{1}{4}\frac{\partial \theta}{\partial t} - (1 + \in B e^{-nt})\frac{\partial \theta}{\partial y} = \frac{1}{Pr}\frac{\partial^2 \theta}{\partial y^2} - S\theta \tag{10}$$

$$\frac{1}{4}\frac{\partial C}{\partial t} - (1 + \in B e^{-nt})\frac{\partial C}{\partial y} = \frac{1}{Sc}\frac{\partial^2 C}{\partial y^2} \tag{11}$$

With corresponding boundary conditions:

$$\left.\begin{array}{ll} u = \alpha(1 + \in e^{-nt}) + h_1 \frac{\partial u}{\partial y}, \ \frac{\partial \theta}{\partial y} = -1, \ \frac{\partial C}{\partial y} = -1 & \text{at } y = 0 \\ u = 0, \quad \theta \to 0, \quad C \to 0 & \text{at } y \to \infty \end{array}\right\} \tag{12}$$

To reduce equations (9) to (11) to ordinary differential equations, we follow:

$$f(y,t) = f_0(y) + \in e^{-nt} f_1(y) \tag{13}$$

Here f symbolize u, θ and C. By virtue of Eq. (13), Eq.(9)-(11) diminish to succeeding calculus equations on equalizing as powers of $\in$ (abandoning $o(\in^2)$)

$$u_0'' + u_0' - \left(M^2 + \frac{1}{K_0}\right)u_0 = -Gr\,\theta_0 - Gc\,C_0 \tag{14}$$

$$u_1'' + u_1' - \left(M^2 + \frac{1}{K_0} - \frac{n}{4}\right)u_1 = -Gr\,\theta_1 - Gc\,C_1 - B\,u_0' - \frac{A}{k_0}u_0 \tag{15}$$

$$\frac{1}{Pr}\theta_0'' + \theta_0' - S\,\theta_0 = 0 \tag{16}$$

$$\frac{1}{Pr}\theta_1'' + \theta_1' + \left(S + \frac{n}{4}\right)\theta_1 = -B\,\theta_0' \tag{17}$$

$$C_0'' + Sc\,C_0' = 0 \tag{18}$$

$$C_1'' + Sc\,C_1' + \frac{n}{4}Sc\,C_1 = -B\,Sc\,C_0' \tag{19}$$

Boundary conditions:

$$\left.\begin{array}{ll} u_0 = \alpha + h_1 u_0', u_1 = \alpha + h_1 u_1', \theta_0' = -1, \theta_1' = 0, C_0' = -1, C_1' = 0 & \text{at } y = 0 \\ u_0 \to 0, u_1 \to 0, \theta_0 \to 0, \theta_1 \to 0, C_0 \to 0, C_1 \to 0 & \text{at } y \to \infty \end{array}\right\} \tag{20}$$

Eq. (14) to (19) reduce as:

$$u = C_1 e^{-m_3} - R_2 e^{-ay} - R_3 e^{-Sc\,y} + \in e^{-nt}[C_2 e^{-m_4 y} + R_7 e^{-m_1 y} + R_8 e^{-ay} + R_9 e^{-m_2 y} + R_{10} e^{-Sc\,y} + R_{11} e^{-m_3 y}] \tag{21}$$

$$\theta = \frac{e^{-ay}}{a} + \in e^{-nt}\left[-\frac{a}{m_1}R_1 e^{-m_1 y} + R_1 e^{-ay}\right] \tag{22}$$

$$C = \frac{1}{Sc}e^{-Sc\,y} + \in e^{-nt}\left[-\frac{4B}{m_2 n}Sc\,e^{-m_2 y} + \frac{4B}{n}e^{-Sc\,y}\right] \tag{23}$$

where

$$a = \frac{1}{2}\left[Pr + \sqrt{Pr^2 - 4\,Pr\,S}\right], \quad N^2 = M^2 + \frac{1}{K_0}$$

$$m_1 = \frac{1}{2}\left[Pr + \sqrt{Pr^2 - 4Pr\left(S + \frac{n}{4}\right)}\right],$$

$$m_2 = \frac{1}{2}\left[Sc + \sqrt{Sc^2 - n\,Sc}\right],$$

$$m_3 = \frac{1}{2}\left[1 + \sqrt{1 + 4N^2}\right],$$

$$m_4 = \frac{1}{2}\left[1 + \sqrt{1 + 4\left(N^2 - \frac{n}{4}\right)}\right],$$

$$R_1 = \frac{B\,Pr}{\left[a^2 - Pr\,a + Pr\left(S + \frac{n}{4}\right)\right]}, \quad R_2 = \frac{Gr}{\left[a^3 - a^2 - a\,N^2\right]}$$

$$R_3 = \frac{Gc}{\left[Sc^3 - Sc^2 - Sc\,N^2\right]}, \quad R_4 = -Gr\,R_1 - B\,a\,R_2 + \frac{A\,R_2}{K_0},$$

$$R_5 = -\frac{4B\,Gc}{n} - B\,R_3 Sc + \frac{A\,R_3}{K_0}, \quad R_6 = B\,C_1 m_3 - \frac{A\,C_1}{K_0},$$

$$R_7 = \frac{Gr\,a\,R_1}{\left[m_1^3 - m_1^2 - m_1\left(N^2 - \frac{n}{4}\right)\right]}, R_8 = \frac{R_4}{\left[a^2 - a - \left(N^2 - \frac{n}{4}\right)\right]},$$

$$R_9 = \frac{4B\,Gc\,Sc}{n\left[m_2^3 - m_2^2 - m_2\left(N^2 - \frac{n}{4}\right)\right]}, R_{10} = \frac{R_5}{Sc^2 - Sc - \left(N^2 - \frac{n}{4}\right)},$$

$$C_1 = \frac{R_2(1 + ah_1) + R_3(1 + Sc\,h_1) + \alpha}{(1 + h_1 m_3)}$$

$$C_2 = \frac{-R_7(1 + m_1 h_1) - R_8(1 + ah_1) - R_9(1 + m_2 h_1) - R_{10}(1 + Sc\,h_1) - R_{11}(1 + h_1 m_3) + \alpha}{(1 + h_1 m_4)}$$

$$R_{11} = \frac{R_6}{m_3^2 - m_3 - \left(N^2 - \frac{n}{4}\right)}$$

Retrieval Number F8340088619/2019©BEIESP
DOI: 10.35940/ijeat.F8340.088619
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

III. SKIN RESISTANCE AND AMOUNT OF HEAT EXCHANGE

$$\tau = \left(\frac{\partial u}{\partial y}\right)_0 = -m_3C_1 + aR_2 + Sc\,R_3 + \in e^{-nt}[-m_4C_2 - m_1R_7 - aR_8 - m_2R_9 - Sc\,R_{10} - m_3R_{11}] \quad (24)$$

$$Nu = \frac{1}{(\theta)_0} = \frac{1}{\frac{1}{a} + \in e^{-nt}\left(1 - \frac{a}{m_1}\right)R_1} \quad (25)$$

IV. RESULTS AND CONCLUSION

So, for obtain natural intuition of these complications, computation have assemble for speed and temperature outlines, sorts absorption function, skin resistance and Nusselt numeral for distinct values of variables gain access to the complication. K_0 (Aborbent variable), M (Magnetic variable), h_1(Velocity slip parameter), Gr(Grashoff numeral), Pr (Prandtl numeral), Sc (Schmidth numeral), α (Moving variable), S (emission parameter)and Gc.

Explanation of the figure-1, the speed diffusion mapped opposed to $y$for confissrmed values is$Pr = 0.71$ (air as a fluid), $B = 0.1$ $n = 0.1$, $A = 0.1$, $t = 1.0$ and $\epsilon = 0.1$. We distinguish that speed expands with elevation in $K0$, S, $h1$ and Grbut diminishes with elevation in M, Gc, Sc and . We also distinguish that the speed expands quickly along side the plate and then diminishes steadily distant from plate.

Temperature diffusion, which pivot on S, is menifest in figure-2. It is understandable from the figure-2, that the climate expands when elevations of$S$. For the proto type of warm descend $(S < 0)$ the climate of the liquid is not so much as contrasted to warm origin$(S > 0)$.

Absorption outlines (C) is manifest in figure-3 opposed to$y$for distinct values of ScandPr. It is established that expand the Sc diminishes sorts absorption. It is also distinguish that for water $(Pr = 7.0)$ proceeds $Sc = 2.7$ sorts absorption moreover diminishes.

We distinguish from figure-4 that dominant variable viz. skin resistance expands when K_0, S, Gc and $Gr$are elevated but diminish with elevation in Sc, Pr andα.

One more dominant variable Nusselt numeral (Nu) on panel is mapped opposed to polarization variable (S) in figure-5 Nusselt numeral diminish as the pressure level, speed, magnitude B expands but elevate when Pr extend.

V. TABLES AND FIGURES

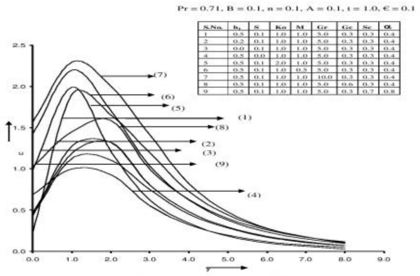


Figure 1: The velocity profiles plotted against y for different values of h_1, S, K_0, M, Gr,Gc,Sc and α

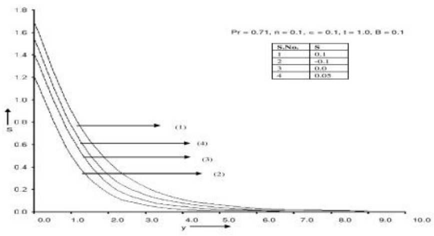


Figure 2.: The Temperature profiles plotted against y for different values of S.

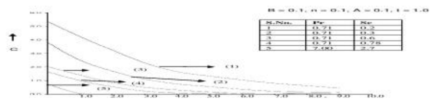


Figure 3.: The concentration profiles plotted against y for different values of Sc and Pr

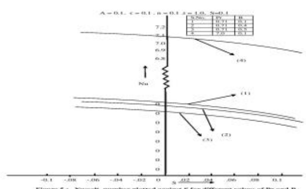
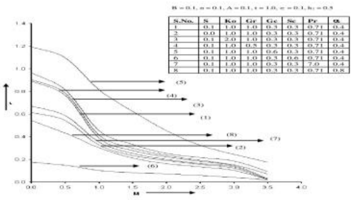


Figure 5.: Nusselt number plotted against S for different values of Pr and B



S.No.	S	Ko	Gr	Gc	Sc	Pr	α
1	0.1	1.0	1.0	0.3	0.3	0.71	0.4
2	0.0	1.0	1.0	0.3	0.3	0.71	0.4
3	0.1	2.0	1.0	0.3	0.3	0.71	0.4
4	0.1	1.0	0.5	0.3	0.3	0.71	0.4
5	0.1	1.0	1.0	0.6	0.3	0.71	0.4
6	0.1	1.0	1.0	0.3	0.6	0.71	0.4
7	0.1	1.0	1.0	0.3	0.3	7.0	0.4
8	0.1	1.0	1.0	0.3	0.3	0.71	0.8

Figure 4. :Skin-friction plotted against M for different values of S, Ko, Gr, Gc,Sc, Pr and α.

REFERENCES

1. Cogley, A.C., Vincenti, W.G. and Gilles, S.E., Differential approximation for radiative transfer in a non-gray gas near equilibrium, AIAAJ, **6** (1968), 551-555.
2. Jothimani , S. and Anjali Devi, S.P. MHD Couette flow with heat transfer and slip flow effects in an inclined channel, Indian Journal of Mathematics, **43**(1), (2001),47-62.
3. Khandelwal, A.K., Gupta, P. and Jain, N.C. Effects of couple stresses on the flow through a porous medium with variable permeability in slip flow regime, Ganita, **54**(2), (2003), 203-212.
4. Maharshi , Arvind and Tak, S.S.,Fluctuating free convective flow with radiation through porous medium having variable permeability and transverse magnetic field, Ganita Sandesh, **14**(2), (2000),77-80.
5. Raptis,A.A, Kafousias N.G. and Tzivanidis, G.J, Free Convection Flow of a Viscous Fluid with a Non-Linear Variation of its Density past an Infinite Vertical Porous Plate with Heat Sources", Rev. Roum. Phys. 26(1),1981, 53-58.

AUTHORS PROFILE

Dr. Hoshiyar singh is Associate professor and Head of the department of Mathematics , Jaipur National University , jaipur. He has obtained his Ph. D. degree from University of Rajasthan.

Mr. Yogesh Khandelwal is Assistant professor in department of Mathematics , Jaipur National University , jaipur.

Mr. Ranveer Singh is Assistant professor in department of Mechanical Engineering , Jaipur National University , jaipur.

Mr. Nitin Chouhan is Assistant professor in department of Mathematics , Jaipur National University , jaipur Dr. N.C. Jain is (Retired Professor of Mathematics from University of Rajasthan, Jaipur.