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Effect of Porosity and Buoyancy Ratio Parameter for Aiding and Opposing Flows in MHD Stokes Problem in Porous Medium

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Abstract – Stream, warmth and mass exchange driven by lightness, in permeable media has been concentrated broadly lately. This is because of the expanding need in understanding the confounded vehicle measure for use of different fields, which incorporates mathematical designing, building protection, energy preservation, strong framework heat exchangers, filtration interaction, and underground removal of atomic waste materials. Liquid move through permeable media is experienced in various parts of science and designing, going from horticultural, compound, common and oil designing, to food and soil sciences.

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INTRODUCTION

In many interaction ventures, the cooling of strings or sheets of some polymer materials is of significance in the creation line. The pace of cooling can be controlled adequately to accomplish eventual outcomes of wanted qualities by drawing strings, and so forth within the sight of an electrically directing liquid subject to an attractive field.MHD discovers applications in electromagnetic siphons, controlled combination research, precious stone developing, MHD couples and bearing, plasma jets, substance blend and MHD power generators, and so on In the field of force age, MHD course through permeable media is getting significant consideration because of the prospects it offers for a lot higher warm efficiencies in force plants.

OBJECTIVE:

The target of the current examination is to explore the impact of different boundaries like porosity, attractive field, lightness proportion in MHD stream past an incautiously begun endless vertical plate within the sight of variable temperature and mass circulation. The administering conditions include porosity boundary and tackled than by utilizing Laplace-change procedure. Henceforth, the impacts of porosity boundary, attractive field and lightness proportion boundary for helping and restricting streams have been examined.

MATHEMATICAL FORMULATION:

The hydro-attractive progression of a thick incompressible liquid past a rashly begun endless vertical plate with variable temperature and uniform mass appropriation has been examined. Here the - hub is brought the plate the vertically upward way and the - pivot is taken typical to the plate. At first, the plate and liquid are a similar temperature and focus. At time >0, the plate is given an imprudently movement the vertical way against gravitational field with steady speed. The plate temperature and focus are raised directly with time. A cross over attractive field of uniform strength is thought to be applied typical to the plate. The instigated attractive field and gooey dissemination is thought to be irrelevant. At that point Boussinesq's estimate, the stream is represented by the accompanying conditions.

$$\frac{\partial u'}{\partial t'} = g\beta(T'-T'_{\infty}) + g\beta(C'-C'_{\infty}) + \nu\frac{\partial^2 u'}{\partial y'^2} - \frac{\sigma B_0^2}{\rho}u' - \frac{\mu}{K'}u' \qquad (1)$$

$$\rho C_p \frac{\partial T'}{\partial t'} = K\frac{\partial^2 T'}{\partial y'^2} \qquad (2)$$

$$\frac{\partial C'}{\partial t'} = D\frac{\partial^2 C'}{\partial y'^2} \qquad (3)$$

With following starting and limit conditions:

$$t' \le 0;\ u'=0;\ T'=T'_{\infty};\ C'=C'_{\infty} \text{ for all } y'.$$

$$t'>0;\ u'=u_0;\ T'=T'_{\infty}+(T'_w-T'_{\infty})At';\ C'=C'_{\infty}+(C'_w-C'_{\infty})At' \text{ at } y'=0.$$

$$u'=0;\ T'\to T'_{\infty};\ C'\to C'_{\infty} \text{ as } y'\to\infty. \qquad (4)$$

On presenting the accompanying non-dimensional amounts in conditions (1) to (4),

We have

$$\frac{\partial u}{\partial t} = \theta + NC + \frac{\partial^2 u}{\partial y^2} - M_k u \qquad (6)$$

$$\frac{\partial \theta}{\partial t} = \frac{1}{\Pr}\frac{\partial^2 \theta}{\partial y^2} \qquad (7)$$

$$\frac{\partial C}{\partial t} = \frac{1}{Sc}\frac{\partial^2 C}{\partial y^2} \qquad (8)$$

Where

$$M_k = M + rk''^2$$

The underlying and limit conditions in dimensionless structure are $u=0;\ \theta=0;\ C=0$ for all $y, t \le 0$

$$u=0;\ \theta=0;\ C=0 \qquad \text{for all } y, t \le 0 .$$

$$u=\frac{1}{Gr};\quad \theta=t;\ C=t \qquad at\ y=0. \qquad (9)$$

$$\}\quad \text{for } t > 0;$$

$$u=0;\ \theta \to 0;\ C \to 0 \qquad as\ y \to \infty.$$

All the actual factors are characterized in the terminology.

$$\theta = t\left[\left(1+2\eta^2 \Pr\right)erfc\left(\eta\sqrt{\Pr}\right) - 2\eta\sqrt{\frac{\Pr}{\pi}}\exp\left(-\eta^2 \Pr\right)\right] \qquad (10)$$

$$\frac{1}{Gr} - \frac{1}{aM_k} - \frac{2t}{M_k} - \frac{1}{bM_k}\Big)$$

$$\text{:p}\left(2\eta\sqrt{M_k t}\right)erfc\left(\eta+\sqrt{M_k t}\right) + \exp\left(-2\eta\sqrt{M_k t}\right)erfc\left(\eta-\sqrt{M_k t}\right)\Big]$$

$$\frac{\eta\sqrt{t}}{\text{ſ}_k\sqrt{M_k}}\left[\exp\left(-2\eta\sqrt{M_k t}\right)erfc\left(\eta-\sqrt{M_k t}\right) - \exp\left(2\eta\sqrt{M_k t}\right)erfc\left(\eta+\sqrt{M_k t}\right)\right]$$

$$\frac{1}{\text{ſ}_k}erfc\left(\eta\sqrt{\Pr}\right) + \frac{N}{bM_k}erfc\left(\eta\sqrt{Sc}\right)$$

$$\frac{\text{p}(at)}{\text{ı}M_k}\left[\begin{array}{l}\exp\left(2\eta\sqrt{(M_k+a)t}\right)erfc\left(\eta+\sqrt{(M_k+a)t}\right)\\ \qquad + \exp\left(-2\eta\sqrt{(M_k+a)t}\right)erfc\left(\eta-\sqrt{(M_k+a)t}\right)\end{array}\right]$$

$$\frac{\text{exp}(bt)}{bM_k}\left[\begin{array}{l}\exp\left(2\eta\sqrt{(M_k+b)t}\right)erfc\left(\eta+\sqrt{(M_k+b)t}\right)\\ \qquad + \exp\left(-2\eta\sqrt{(M_k+b)t}\right)erfc\left(\eta-\sqrt{(M_k\right.\end{array}\right.$$

$$\frac{}{k}\left[\left(1+2\eta^2 \Pr\right)erfc\left(\eta\sqrt{\Pr}\right) - 2\eta\sqrt{\frac{\Pr}{\pi}}\exp\left(-\eta^2 \Pr\right)\right]$$

$$\frac{}{k}\left[\left(1+2\eta^2 Sc\right)erfc\left(\eta\sqrt{Sc}\right) - 2\eta\sqrt{\frac{Sc}{\pi}}\exp\left(-\eta^2 Sc\right)\right]$$

$$\frac{\text{xp}(at)}{aM_k}\left[\exp\left(2\eta\sqrt{a\Pr t}\right)erfc\left(\eta\sqrt{\Pr}+\sqrt{at}\right) + \exp\left(-2\eta\sqrt{a\Pr t}\right)erfc\left(\eta\sqrt{\Pr}-\sqrt{at}\right)\right]$$

$$-\frac{N\exp(bt)}{2bM_k}\left[\exp\left(2\eta\sqrt{bSct}\right)erfc\left(\eta\sqrt{Sc}+\sqrt{bt}\right) + \exp\left(-2\eta\sqrt{bSct}\right)erfc\left(\eta\sqrt{Sc}-\sqrt{bt}\right)\right] \qquad (11)$$

$$C = \frac{t}{M_k}\left[\left(1+2\eta^2 Sc\right)erfc\left(\eta\sqrt{Sc}\right) - 2\eta\sqrt{\frac{Sc}{\pi}}\exp\left(-\eta^2 Sc\right)\right] \qquad (12)$$

Where

$$a = \frac{M_k}{\Pr - 1},\quad b = \frac{M_k}{Sc-1},\quad and\quad \eta = \frac{y}{2\sqrt{t}}.$$

RESULTS AND DISCUSSION:

The mathematical estimations of the speed and skin-grinding are registered for various boundaries like attractive field parameters and lightness proportion boundaries. The motivation behind the estimations given here is to survey the impacts of the boundaries M and N upon the idea of the stream and transport.

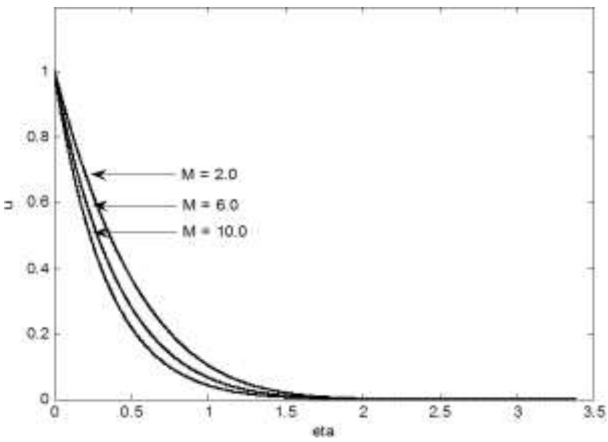

Fig.(1) velocity profile for different M and k" = 1.0

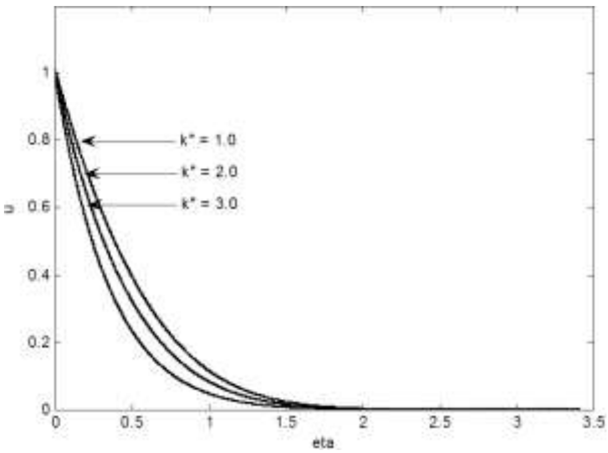

Fig.(2) velocity profile for different k" and M = 1.0

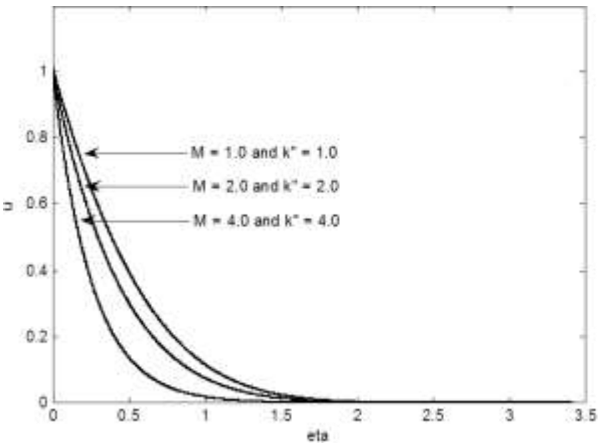

Fig.(3) velocity profile for different M and k".

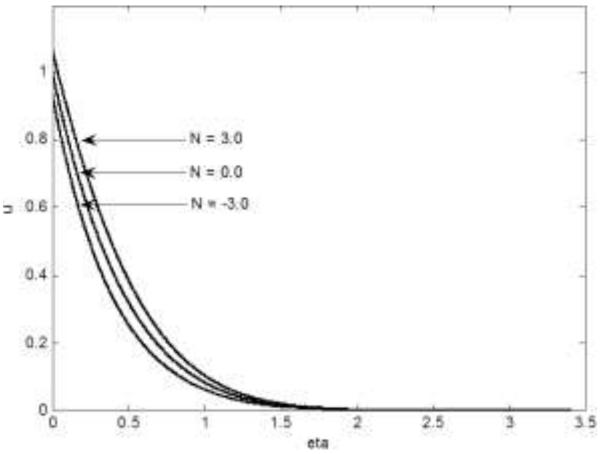

Fig.(4) velocity profile for different M and k".

From the velocity field, we now study the skin-friction. It is given by

$$\tau = -\left(\frac{du}{dy}\right)_{y=0} = -\frac{1}{2\sqrt{t}}\left(\frac{du}{d\eta}\right)_{\eta=0} \qquad (13)$$

and equations (11) and (13) give, the wall shear stress in the presence of magnetic field and porosity parameters are as follows:

$$\tau = \frac{1}{\sqrt{\pi t}}\left[\begin{array}{l} \left(\frac{1}{Gr}-\frac{1}{aM_k}-\frac{2t}{M_k}-\frac{N}{bM_k}\right)\left(\sqrt{M_k \pi t}\, erf\left(\sqrt{M_k t}\right)+1\right) \\ +\frac{\sqrt{\pi t}}{2M_k\sqrt{M_k}}\, erf\left(\sqrt{M_k t}\right)+\frac{\sqrt{\Pr}}{aM_k}+\frac{N\sqrt{Sc}}{bM_k}+\frac{2t\sqrt{\Pr}}{M_k}+\frac{2t\sqrt{Sc}}{M_k} \\ +\frac{\exp(at)}{aM_k}\left(\begin{array}{l}1-\sqrt{\Pr}+\sqrt{(M_k+a)\pi t}\, erf\left(\sqrt{(M_k+a)t}\right) \\ -\sqrt{\Pr \pi a t}\, erf\left(\sqrt{at}\right)\end{array}\right) \\ +\frac{N\exp(bt)}{bM_k}\left(\begin{array}{l}1-\sqrt{Sc}+\sqrt{(M_k+b)\pi t}\, erf\left(\sqrt{(M_k+b)t}\right) \\ -\sqrt{Sc \pi b t}\, erf\left(\sqrt{bt}\right)\end{array}\right) \end{array}\right] \quad ...(14)$$

The numerical values of skin-friction τ :for (Gr = 1, Sc = 2.01, $\Pr$ = 7).

k"	M'	N	t	τ
0	1	2	0.2	0.9733
1	1	2	0.2	1.6899
2	1	2	0.2	2.8768
2	1	0	0.2	3.0233
2	1	-5	0.2	3.3897
2	1	-10	0.2	3.7560
2	1	2	0.4	2.4548

It has been seen that skin-grating increments with expanding estimations of the porosity boundary. This shows that the divider shear pressure increments with expanding porosity boundary. This pattern is simply turned around concerning time. It is additionally seen that the skin-contact increments within the sight of contradicting stream and diminishes with supporting streams.

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Nomenclature			
A	constant	t'	time
B_0	external magnetic field	t	dimensionless time
C'	species concentration in the fluid	u'	velocity of the fluid in the x'- direction
C_w	concentration of the plate	u_0	velocity of the plate
C_∞	concentration of the liquid far away from the plate	u	dimensionless velocity
C	dimensionless concentration	y'	coordinate axis normal to the plate
C_p	specific heat at constant pressure	y	dimensionless coordinate axis normal to the plate
g	acceleration due to gravity	β	volumetric coefficient of thermal expansion
Gr	thermal grash of number	β^*	volumetric coefficient of expansion with concentration
Gm	mass grashof number	μ	coefficient of viscosity
k	thermal conductivity of the fluid	ν	Kinematic viscosity
M'	magnetic field parameter	ρ	density of the fluid
N	buoyancy ratio parameter	σ	electric conductivity
Pr	prandtl number	τ'	skin-friction
Sc	Schmidt number	τ	dimensionless skin friction
T'	temperature of the fluid near the plate	θ	dimensionless temperature
T_w	temperature of the plate	η	similarity parameter
T_∞	temperature of the fluid far away from the plate	k'	permeability of the medium
L	characteristic length	k^*	porosity of the medium

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