International Journal of Scientific Research & Engineering Trends
Volume 9, Issue 3, May-Jun-2023, ISSN (Online): 2395-566X

Couette Flow on Porous Surface with Heat Transfer

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Abstract- This research investigates the steady, laminar Couette flow of a viscous incompressible fluid through a porous medium bounded by two infinite horizontal parallel plates. A transverse magnetic field and thermal radiation effects are typically incorporated to analyze their impact on the flow and thermal characteristics. the fluid is electrically conducting, the effects of the porosity of the medium, the surface stretching velocity, The heat generation coefficient on both the flow and heat transfer are presented. The governing partial differential equations for momentum and energy are formulated based on Darcy's law.

Keywords- MHD Flow, Porous medium, Heat Transfer, Finite Differences. Hartmann number, Darcy number, Prandtl number, and porosity parameter.

I. INTRODUCTION

The flow is generated by the uniform motion of the upper plate while the lower plate remains stationary. These findings provide critical insights for engineering applications such as transpiration cooling, petroleum technology, and the design of high-temperature heat exchangers. Ahmadi Raptis (1983) discussed about the unsteady flow through a porous medium bounded by an infinite porous plate subjected to a constant suction variable temperature. Attia (2006) discussed the unsteady MHD couette and heat transfer of dusty fluid variable physical properties. Haken (2007) discussed the tuncay yilm two-dimensional natural convection in a porous triangular enclosure with a square body.

Hayat et al (2008) discussed the heat transfer analysis on the MHD flow of a second grad fluid in channel with porous medium. B.K. Dutta (1985): Temperature field in the flow over stretching surface with uniform heat flux. Int. Comm. Heat Mass Transfer, Vol. 12, Pp. 89-103. C. Israel-Cookey, A.Ogulu and V.B.Omubo-Pepple (2003) discussed Influence of viscous dissipation and radiation on unsteady MHD free-convection flow past an infinite heated vertical plate in a porous medium with time-dependent suction. International Journal of Heat and Mass Transfer, Vol. 46, Pp. 2305-2311.

III. MATHEMATICAL ANALYSIS

We consider the 2-D MHD flow in a porous medium of viscous incompressible fluid near a stagnation point at a. the flow being in a region y>0 and we consider two equal and opposing forces along the x-axis and keeping the origin fixed. The potential flow arrives from the y-axis. The viscous flow must adhere to the wall, where as the potential slides along it. (u',v') are the components for the potential flow of velocity at the point (x',y') for the viscous flow, where as (U,V) are the components for the potential flow.

The velocity distribution in the frictionless MHD flow is given by

$$U(x') = dx', \quad V(x') = -dy' \qquad \dots (1)$$

The continuity and momentum equation

$$\frac{\partial u'}{\partial x'} + \frac{\partial v'}{\partial y'} = 0 \qquad \dots (2)$$

$$\rho\left(u'\frac{\partial u'}{\partial x'} + v'\frac{\partial u'}{\partial y'}\right) = U\frac{dU}{dx'} + \left(\mu\frac{\partial^2 u'}{\partial y'2}\right) + \frac{\mu^2}{K}U(x') - \left(\frac{\mu^2}{K} + \frac{\sigma\beta_0^2}{\rho^2}\right)u' \qquad \dots (3)$$

The boundary condition of above flow problem is given by

$$y' = 0 : \; u' = cx', \; v' = 0$$
$$y' \to \infty : \; u' \to dx' \qquad \dots (4)$$

The continuity and momentum equations admit a similarity solution

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$$u'(x',y') = cxf'(\eta), \quad v = -\sqrt{c\upsilon}\, f(\eta), \quad \eta = \sqrt{\frac{c}{\eta}}\, y' \qquad \ldots (5)$$

Where $\upsilon = \mu/\rho$ is the kinematics viscosity of fluid and prime denotes the differentiation with respect to η. Using equation (4) the continuity equation (2) is satisfied and using (4) and (5) the equation (3) reduce in the form

$$f'^2 - f''' - ff'' - \frac{C^2}{\rho} - \varepsilon(C-1) + \frac{MU}{cd} f' = 0 \qquad \ldots(6)$$

$\varepsilon = \dfrac{\nu}{cK}$ porosity of medium

$C = \dfrac{a}{c}$ stretching parameter

$M = \dfrac{\beta_0}{V}\sqrt{\dfrac{\sigma}{\mu}}$ e Hartmann number

d = wave length

$\square$ -The density ,$\square$0 -magnetic field component K -Darcy permeability ,$\square$ is the electric conductivity of porous medium.

And the boundary of this situation

$$f(0)=0, \quad f'(0)=1, \quad f'(\infty) = C \quad \ldots(7)$$

The energy equation of such problem is given by

$$\rho Cp\left(u'\frac{\partial T'}{\partial x'} + U\frac{\partial T'}{\partial y'}\right) = K^2 \frac{\partial^2 T'}{\partial y'^2} + Q(T' - T_\infty)$$

… (8)

Where Cp is the heat capacity at pressure of fluid,
K, is thermal conductivity of fluid, , The constant temperature far away from the stretching surface, Q, the volumetric rate of heat generation,

$$\left.\begin{array}{l} y'=0; \quad T'=T_w^1; \quad \theta^* = \dfrac{T'-T_\infty^1}{T_w^* - T_\infty^*} \\ y' \to \infty; \quad T' = T_\infty^1 \end{array}\right\}$$

T, is the temperature profile,
Tw and are the wall and stream temperature respectively are constant.
The thermal boundary conditions are

$$\left.\begin{array}{l} y'=0; \quad T'=T_w^1; \quad \theta^* = \dfrac{T'-T_\infty^1}{T_w^* - T_\infty^*} \\ y' \to \infty; \quad T' = T_\infty^1 \end{array}\right\} \qquad \ldots (9)$$

Applying the boundary (9) the energy equation (8) reduced in the form

$$\theta'' + \Pr(f\theta' + B\theta) = 0 \qquad \ldots (10)$$

III. RESULTS AND DISCUSSION

Figure (1) and (2) shows the velocity profile for varies values of C and M. these figure shows that increasing the parameter C then increasing both f and f/. Whenever C<1 and increasing M then increasing f and f/. Whenever C>1, increasing M then decreasing both f and f/. These figures show the effect of C on both f and f/. More ever, increasing C then decreasing the boundary layer thickness. Figure (3) represent the temperature $\square$ for varies value of c and M and for Pr = 0.6 and B =0.1. It is clear that increasing C decreasing$\square$.

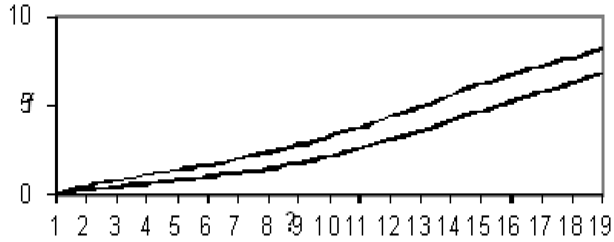

Fig. 1 Effect of the parameters C and M on the profile of f

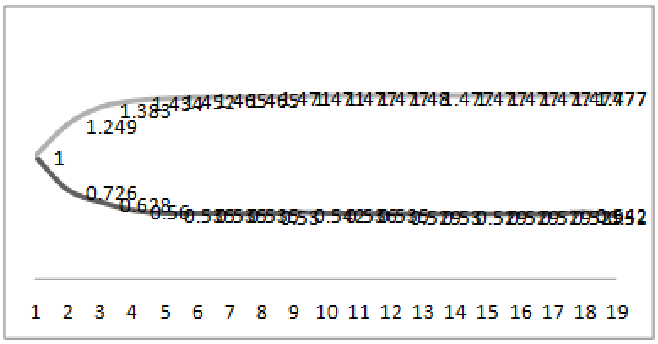

Fig. 2 Effect of the parameters C and M on the profile of

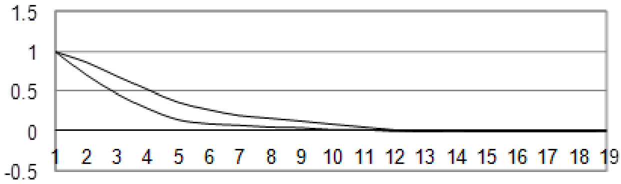

Fig.-3 temperature distribution

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