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Effect of slip velocity on oscillatory MHD flow with radiative heat transfer and variable suction.

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Cookey et al. (2003) proposed a model for the study of MHD free convection flow past an infinite heated vertical plate in a porous medium in which they observed that increased cooling of the plate was accompanied with an increase in the velocity. Taneja and Jain (2002) looked at the Unsteady MHD flow in a porous medium in the presence of radiative heat where they obtained expressions for the velocity, temperature and rate of heat transfer. The study of fluid flow in porous media in the presence of radiative heat is of paramount importance in geothermal engineering and in astrophysics hence a lot of work have been reported in the literature. Cookey et al. (2003) has a good review of some of these works.

In this study we consider the two-dimensional oscillatory flow of an incompressible viscous, radiating, electrically conducting fluid past an infinite vertical wall with constant heat embedded in a porous medium of variable permeability with velocity components (u', v') in the (x', y') direction. It is assumed that a constant magnetic field of uniform strength is applied externally transverse to the direction of flow so that induced magnetic fields are negligible.

Under the usual Boussinesq approximations the proposed governing equations are

$$\frac{1}{4}\frac{\partial u}{\partial t} - (1 + B\varepsilon e^{i\omega t})\frac{\partial u}{\partial y} = G_r\theta + \frac{1}{4}\frac{dU_\infty}{dt} + \frac{\partial^2 u}{\partial y^2} - M^2 u - \frac{u}{k_o(1 + A\varepsilon e^{i\omega t})} \tag{1}$$

$$\frac{1}{4}\frac{\partial \theta}{\partial t} - (1 + B\varepsilon e^{i\omega t})\frac{\partial \theta}{\partial y} = \frac{1}{P_r}\frac{\partial^2 \theta}{\partial y^2} - R_a\theta \tag{2}$$

Subject to the boundary conditions, Shidlovskiy (1961)

$$u = \frac{u_c}{L}x_u, \quad \theta = \theta_w + x_T\frac{\theta_c}{L} \qquad at \quad y = 0$$

$$u \to 0, \quad \theta \to 0 \qquad as \quad y \to \infty \tag{3}$$

$x_u \geq 0$, $x_T \geq 0$, u_c is a characteristic flow velocity, θ_c is a characteristic temperature and L is a characteristic length.

To solve the problem as posed in equations (1) – (3), we seek a perturbative series expansion about ε for our dependent variables. This is justified since ε is small; thus we write

$$u(y,t) = u_o(y) + \varepsilon u_1 e^{i\omega t} + 0(\varepsilon^2) + ... \tag{4}$$

$$\theta(y,t) = \theta_o(y) + \varepsilon \theta_1 e^{i\omega t} + 0(\varepsilon^2) + ... \tag{5}$$

For the stream we have

$$u(y,t) = 1 + \varepsilon e^{i\omega t}$$

Substituting equations (4) and (5) and the expression for the stream into equations (1) and (2) we obtain the equations governing the steady state motion and the equations governing the transient. These two sets of equations are now solved analytically for the velocity and the temperature. Having obtained expressions for the temperature and velocity we then calculate the rate of heat transfer and the skin friction.

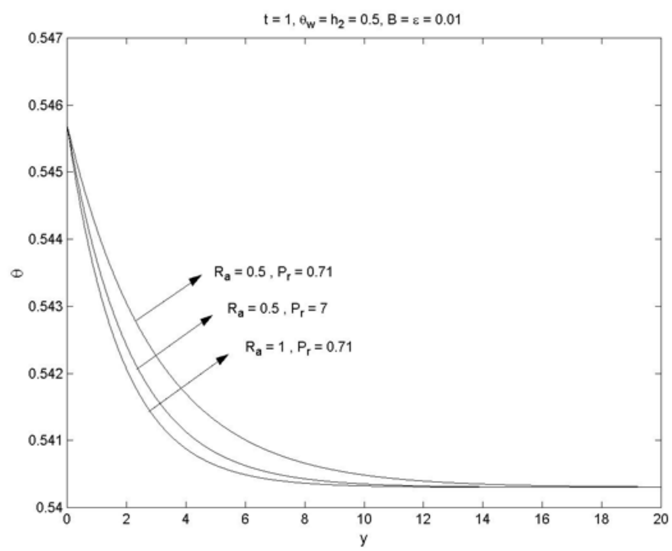

Figure 1: Temperature Profile (Real Part)

Figures 1 and 2 show the temperature distribution for $h_2 = 0.5$ from which we observe the temperature decreases away from the plate. The decrease is greater for a Newtonian fluid ($P_r = 7$) than it is for a non-Newtonian fluid ($P_r = 0.71$). The temperature decreases with increase in the radiation parameter R_a, which is in agreement with the work of Cookey et al. (2003). Furthermore, we observe that the magnitude of the temperature is greater for the imaginary part of the temperature than it is for the real. The temperature increases with increase in the slip parameter h_2.

Our preliminary results for the velocity show that near the plate, the velocity increases rapidly, attains a maximum value, then slowly fades away far from the plate.

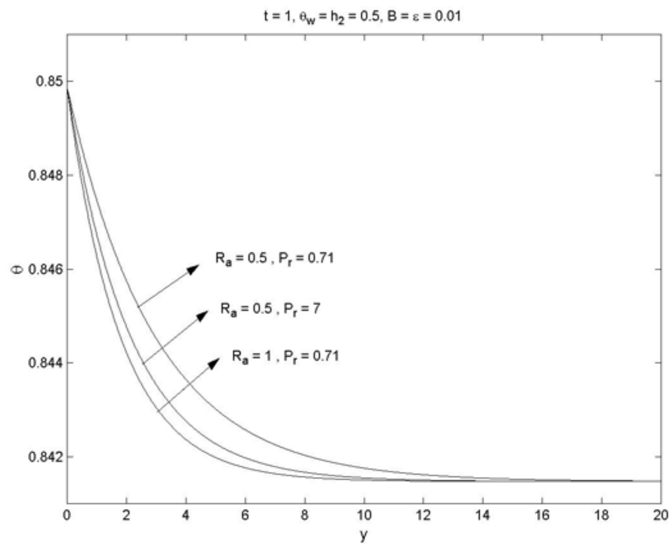

Figure 2: Temperature Profile (Imaginary Part)

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