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The effect of Hall currents and coriolis forces on hydro magnetic two phased flow between two parallel Walls

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ABSTRACT: Numerical calculations of the resulting solutions are performed and by varying the various physical parameters Hartmann number, Hall parameter, viscosity ratio, height ratio and represented graphically to discuss interesting features of the solutions. We observed that an increase Hall parameter increases the primary and secondary velocity distributions for fixed values of the remaining governing parameters.

KEY WORDS: MHD, Hall currents, Ionized Fluids, Two Phases, Viscous.

INTRODUCTION

The most common practical example in which this effect is evident is the pipeline flow of petroleum and water.The purpose of the present study is to gain a detailed understanding of the flow pattern in the theoretical description of MHD two-fluid flow driven by a constant pressure gradient through a horizontal channel consisting of two parallel walls under the influence of a transversely applied uniform strong magnetic field, in presence of Hall currents. This study has been carried out when the walls are made up of non-conducting material.

Basic governing equations with boundary and interface conditions and mathematical analysis of the problem:

The fundamental equations to be solved are the equations of motion and current for the steady state two-fluid flow of neutral fully–ionized gas valid under assumptions given below and simplified as:

(i) The ionization is in equilibrium which is not affected by the applied electric and magnetic fields.

(ii) The effect of space charge is neglected.

(iii) The flow is fully developed and stationary, that is $\partial/\partial t = 0$ And $\partial/\partial x = 0$ except $\partial p/\partial x \neq 0$.

(iv) The magnetic Reynolds number is small [so that the externally applied magnetic field is undisturbed by the fluid, namely the induced magnetic field is small compared with the applied field [Shercliff (1965)]. Therefore components in the conductivity tensor are expressed in terms of B_0.

(v) The flow is two-dimensional, namely $\partial/\partial z = 0$.

With these assumptions, the governing equations of motion and current can be formulated as follows for the two-dimensional steady state problem of study in two regions.

Region– I

$$k_1+\frac{d^2u_1}{dy^2}-\left(\frac{1}{1+m^2}\right)H_a{}^2(mz+u_1)+\left(\frac{m}{1+m^2}\right)H_a{}^2(mx-w_1)=0,$$

$$k_2+\frac{d^2w_1}{dy^2}+\left(\frac{1}{1+m^2}\right)H_a{}^2(mx-w_1)+\left(\frac{m}{1+m^2}\right)H_a{}^2(mz+u_1)=0,$$

$$I_x=\left(\frac{1}{1+m^2}\right)(m_x-w_1)+\left(\frac{m}{1+m^2}\right)(m_z+u_1)-\frac{s}{H_a^2}\left(\frac{m}{1+m^2}\right),$$

$$I_z=\left(\frac{1}{1+m^2}\right)(m_z+u_1)-\left(\frac{m}{1+m^2}\right)(m_x-w_1)+\frac{s}{H_a^2}\left(1-\frac{m}{1+m^2}\right),$$

Region –II

$$\beta_1\alpha h^2+\frac{d^2u_2}{dy^2}-\left(\frac{1}{1+m^2}\right)\alpha\sigma_1h^2H_a{}^2(mz+u_2)+$$

$$\left(\frac{m}{1+m^2}\right)\alpha\sigma_2h^2H_a{}^2(mx-w_2)=0,$$

$$\beta_2\alpha h^2+\frac{d^2w_2}{dy^2}-\left(\frac{1}{1+m^2}\right)\alpha\sigma_1h^2H_a{}^2(mx-w_2)+$$

$$\left(\frac{m}{1+m^2}\right)\alpha\sigma_2h^2H_a{}^2(mz+u_2)=0,$$

$$I_x=\left(\frac{\sigma_0\sigma_1}{1+m^2}\right)(m_x-w_2)+\left(\frac{m\sigma_2\sigma_0}{1+m^2}\right)(m_z+u_2)-\frac{s\sigma^2{}_0\sigma_2}{H_a^2}\left(\frac{m}{1+m^2}\right),$$

$$I_z=\left(\frac{\sigma_1\sigma_0}{1+m^2}\right)(m_z+u_2)-\left(\frac{m\sigma_2\sigma_0}{1+m^2}\right)(m_x-w_2)+\frac{s\sigma_0}{H_a^2}\left(1-\frac{\sigma_1\sigma_0}{1+m^2}\right),$$

where, $k_1=1-s\left(\frac{m^2}{1+m^2}\right)$; $k_2=\frac{-sm}{1+m^2}$, $\beta_1=1-s\left(1-\frac{\sigma_0\sigma_1}{1+m^2}\right)$; $\beta_2=\left(\frac{-s\sigma_0\sigma_2m}{1+m^2}\right)$,

$I_x+iI_z=\frac{J_x+iJ_z}{\sigma_{0i}B_0u_p}$. (i=1,2)

The non-dimensional forms of the velocity, temperature and interface boundary conditions become:

$$u_1(+1)=0, w_1(+1)=0, \tag{1}$$

$$u_2(-1)=0, w_2(-1)=0, \tag{2}$$

$$u_1(0) = u_2(0), w_1(0) = w_2(0), \tag{3}$$

$$\frac{du_1}{dy} = \frac{1}{\alpha h}\frac{du_2}{dy} \text{ and } \frac{dw_1}{dy} = \frac{1}{\alpha h}\frac{dw_2}{dy} \text{ at y=0.} \tag{4}$$

The conditions (1) and (2) represent the no-slip conditions at the walls. The conditions (3) and (4) represent the continuity of velocity and shear stress at the interface y=0.

Solutions of the problem

Exact solutions of the governing differential equations with the help of boundary and interface conditions for the primary and secondary velocities u_1, u_2 and w_1, w_2 respectively. The numerical values of the expressions given at equations and computed for different sets of values of the governing parameters involved in the study and these results are presented graphically from figures 1and 2, also discussed in detail.

Results and discussion

Figs.1and 2 exhibits the effect of varying Hall parameter 'm' on both primary and secondary velocity distributions respectively. From fig.1, it is found that an increase in 'm' increases the primary velocity distributions in the two regions, while the secondary velocity distribution increases as 'm' increases up to, say 3 and beyond this it decreases (fig.2). Also it is observed that, the maximum velocity in the channel tends to move above the channel centerline towards region-I (fluid in the upper region) as the Hall parameter increases in the case of secondary velocity distribution (fig 2).

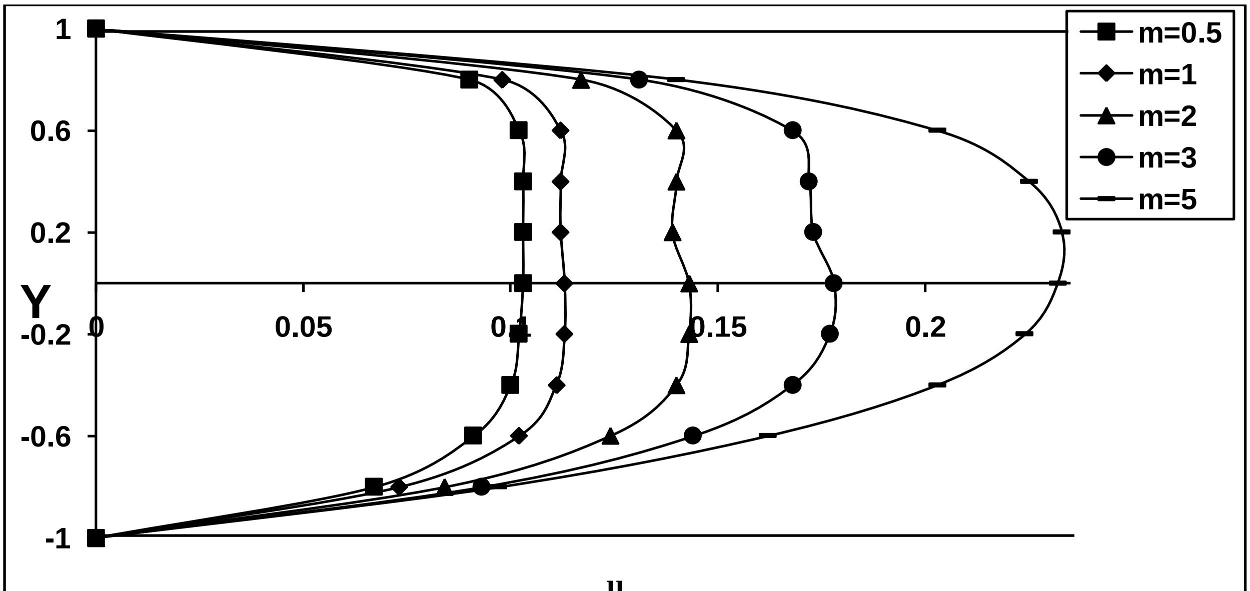

Fig.1 Primary Velocity profiles for different Hall perameter (m) and H_a=10, α=0.333, σ_0=2, σ_1=1.2, σ_2=1.5, h=0.8.

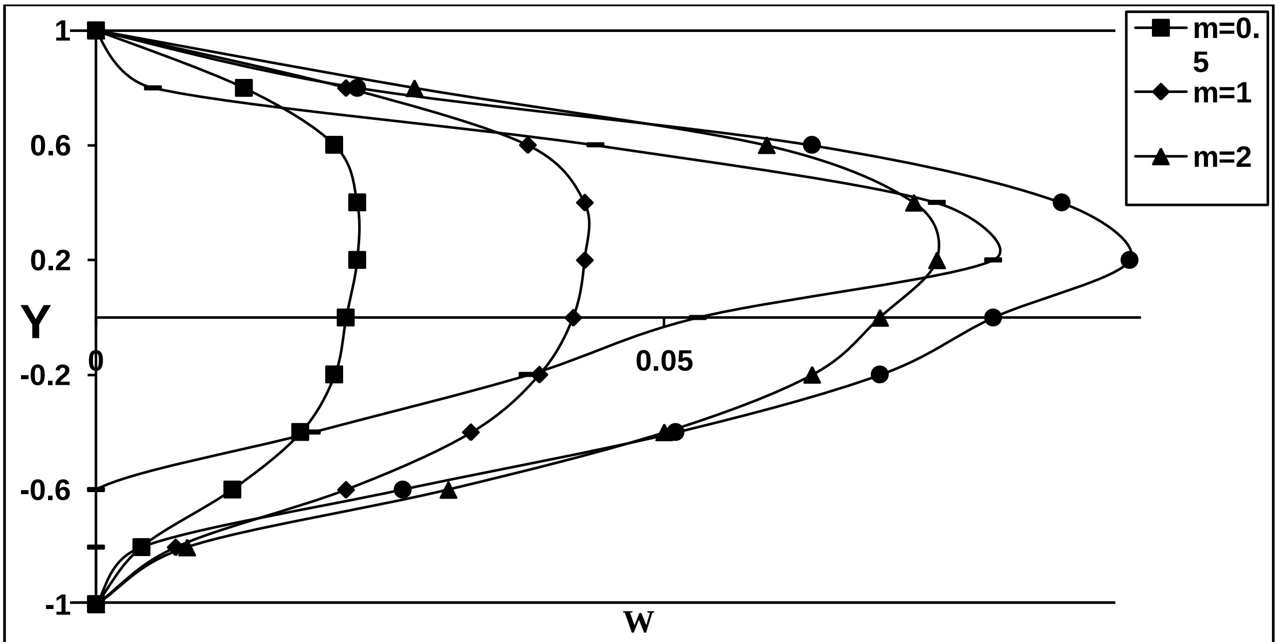

Fig.2 Secondary Velocity profiles for differet Hall parameter (m) and H_a=10, α=0.333, s_0=2, s_1=1.2, s_2=1.5, h=0.3.

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