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MHD Two Fluid Channel flow in Two Parallel Conducting Walls

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ABSTRACT

The main objective of this study is to extend the applicability of existing MHD two-fluid flow models by incorporating the Taylor number to emphasize more on such studies as these are essential for solving many engineering and industrial problems in relation to the rotating MHD generators, Hall accelerators, pumps and flow-meters, space craft design. The resulting governing linear differential equations are solved analytically, using the prescribed boundary and interface conditions to obtain the exact solutions for velocity distributions such as primary and secondary distributions in both regions. Also, their corresponding numerical results for various sets of values of the governing parameters are obtained to represent them graphically and are discussed in detail.

Basic governing equations with boundary, 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 neglecting the asterisks, the non-dimensional forms of equations are 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.

With the above transformations and for simplicity, neglecting the asterisks, the non-dimensional forms of equations are become:

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Region I:

$$\frac{1}{P_r}\ \frac{d^2\theta_1}{dy^2} = -\left\{\left(\frac{du_1}{dy}\right)^2 + \left(\frac{dw_1}{dy}\right)^2 + H_a^2 I_1{}^2\right\}, \qquad I_1{}^2 = I_{x_1}{}^2 + I_{z_1}{}^2,$$

Region II:

$$\frac{d^2\theta_2}{dy^2} = -\frac{\beta}{\alpha}\left[\left(\frac{du_2}{dy}\right)^2 + \left(\frac{dw_2}{dy^2}\right)\right] + h^2\sigma\beta H_a^2 I_2{}^2,$$

$$I_2{}^2 = I_{x_2}{}^2 + I_{z_2}{}^2,$$

The boundary conditions are

$$\theta_1(1) = 0,$$

$$\theta_2(-1) = 0,$$

$$\theta_1(0) = \theta_2(0),$$

$$\frac{d\theta_1}{dy} = \frac{1}{\beta h}\frac{d\theta_2}{dy}, \text{ at } y = 0.$$

I. 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.

II. RESULTS AND DISCUSSION

The effect of varying the Hartmann number on temperature distributions in the two regions, (that is, for two-fluids) in the case of s=0 is shown in Fig.1. It is observed in both the regions that, an increase in Hartmann number increases the temperature distribution. Also it is noticed that the temperature profile in the channel moves above the channel centerline towards region-I i.e., profile is high in the upper region compared to the lower region for Hartmann number Ha when all the remaining parameters are fixed.

Fig.2 exhibit the effect of varying Hall parameter ‘m’ on temperature distributions in the case of s=0. From the figure, it is found that an increase in ‘m’ decreases the temperature distribution in the two regions. Also it is

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noticed that the temperature distribution is high in the upper region compared to the lower region for small values of Hall parameter (for m= 0.05 and 1) when all the remaining parameters held fixed.

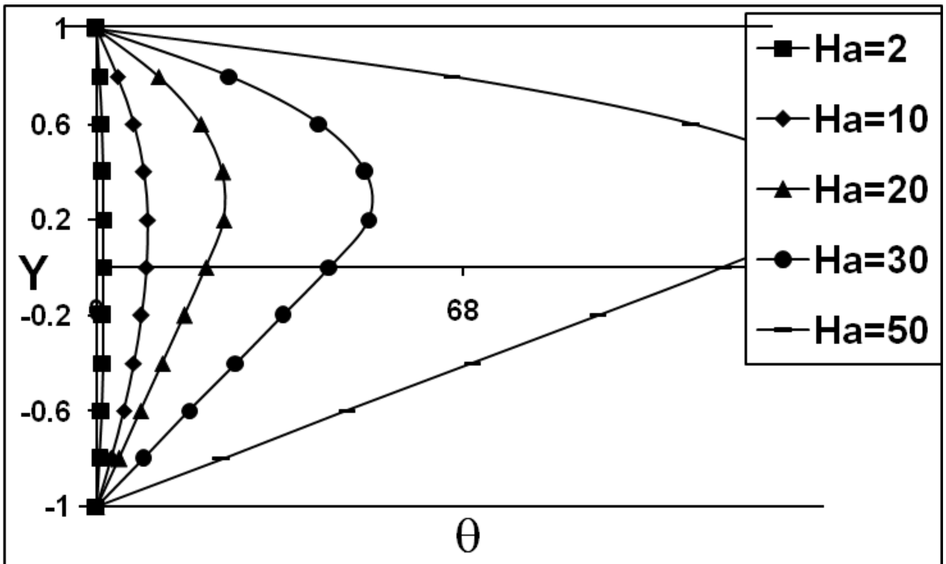

Fig. 1 Temperature profiles for different H_a and
$a=0.333$, $s_0=2$, $s_1=1.2$, $s_2=1.5$, $h=0.8$, $b=1$, $m=2$, $s=0$.

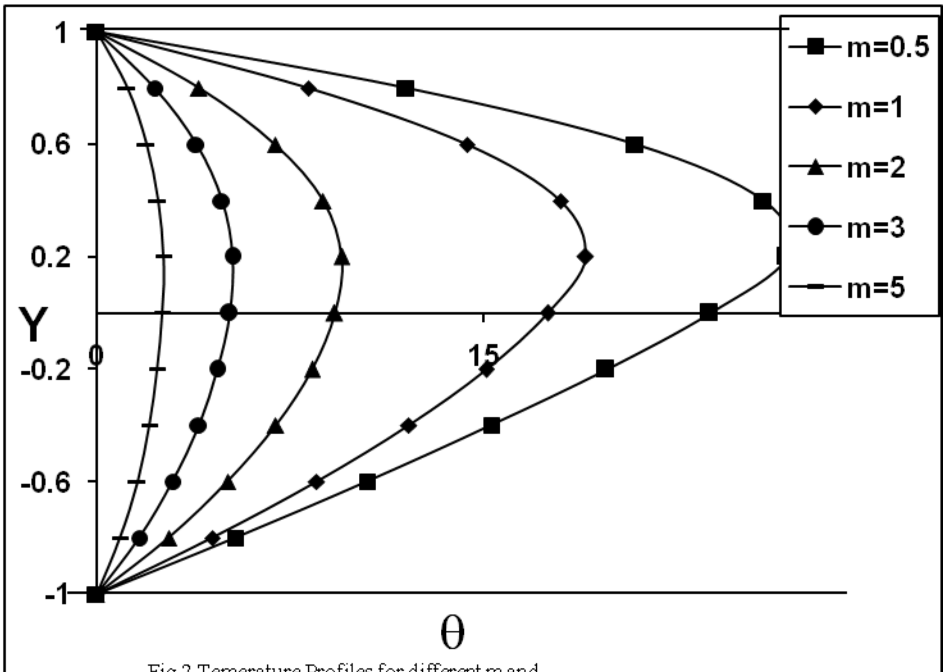

Fig. 2 Temerature Profiles for different m and
$H_a=10$, $a=0.333$, $s_0=2$, $s_1=1.2$, $s_2=1.5$, $b=1$, $h=0.8$, $s=0$.

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