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Commentary

Comment on "Combined heat and mass transfer by mixed convection magnetohydrodynamic (MHD) flow along a porous plate with chemical reaction in presence of heat source" by Zueco, J. and Ahmed, S., 2010, [Appl. Math. Mech. -Engl. Ed. 31(10), pp. 1217-1230]

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In this paper, we demonstrate that the previously reported effect of the transverse magnetic field on a steady mixed convective heat and mass transfer flow of an incompressible viscous fluid past an infinite vertical isothermal porous plate considering the induced magnetic field with viscous and magnetic dissipations of energy by Zueco and Ahmed (2010) [Appl. Math. Mech. -Engl. Ed. 31(10), pp. 1217-1230] has some major flaws. We show that the results included in the paper by Zueco and Ahmed (2010) are incorrect both from a theoretical and practical point of view.

Key words: Magnetohydrodynamic (MHD), induced magnetic field, heat source, magnetic Prandtl number.

INTRODUCTION

In the paper "Combined heat and mass transfer by mixed convection magnetohydrodynamic (MHD) flow along a porous plate with chemical reaction in presence of heat source" by Zueco, J. and Ahmed, S., 2010, [Appl. Math. Mech. -Engl. Ed. 31(10), pp. 1217-1230], the steady mixed convective magnetohydrodynamic (MHD) flow of an incompressible viscous electrically conducting fluid past an infinite vertical porous plate taking into account the induced magnetic field has been studied. Results have been presented for the case of air at 20°C with Prandtl numbers of 0.71. However, there are fundamental errors in this paper and the presented results do not have any practical value. This argument is explained below:

(1) On page number 1219, it is assumed that “the magnetic Prandtl number is greater than the Hartmann number” but in Figures 2, 4 and 5, Prandtl number (Pr_m)= Hartmann number (M)=0.1 and in Figures 6 to 9, M > Pr_m (M=0.25, 0.5 and 0.75 while Pr_m =0.1), which are conflicting with its original assumption.
(2) On page number 1223, it is mentioned that "since Ec < 1 for all the incompressible fluids". However, on page number 1227 to 1228, the values of Ec are taken 0.5, 1.0 and 1.5 in Figure 8.

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(3) The important new thing in this work is the assumption that the electrically conducting fluid induces a new magnetic field, however, the importance of the induced magnetic field depends on the magnetic Reynolds number which is defined as follows (Davidson, 2006):

$$R_m = \mu \sigma u l, \quad (1)$$

where, μ is the magnetic permeability, σ is the fluid electrical conductivity, u is the characteristic velocity of the flow, and l is the characteristic length scale. When the magnetic Reynolds number is much smaller than unity ($R_m \ll 1$) the induced magnetic field is negligible and the imposed external magnetic field is unaffected by the moving conducting fluid (Davidson, 2006).

In most laboratory experiments or industrial processes R_m is very low, usually less than 10^{-2} (Knaepen et al., 2003). In contrast, when the magnetic Reynolds number is equal to or greater than unity ($R_m \gg 1$) the induced magnetic field is important and should be taken into account. Indeed certain applications, such as advanced schemes for the control of magnetogasdynamic flows around hypersonic vehicles, involve values of R_m of the order 1 to 10 (Knaepen et al., 2003).

In the above work, the authors took into account the induced magnetic field without any reference to the magnetic Reynolds number which is the one of the suitable criterion otherwise. Let us calculate here R_m for air at 20°C. Air electrical conductivity at 20°C is 3×10^{-15} to 8×10^{-15} $\Omega^{-1}m^{-1}$ (Pawar et al., 2009), whereas air magnetic permeability is 1.257×10^{-6} Vs /Am, (Magnabosco et al., 2006). For a typical velocity u =1.0 m/ s and a typical length scale l=0.1 m, the magnetic Reynolds number (dimensionless) is:

$$R_m \cong 3.8\times 10^{-22} \quad (2)$$

Instead of using the above magnetic Reynolds number, the authors used the parameter Pr_m named as Magnetic Prandtl number (dimensionless) (Sharma, 2012),

$$\mathrm{Pr}_m = \sigma \mu \nu, \quad (3)$$

Where, ν is the fluid kinematic viscosity. All the presented results are for air corresponding to Pr_m =0.1 to 2.

Let us calculate the Pr_m for air at 20°C. The air kinematic viscosity at 20°C is 1.827×10^{-5} m^2/s (Hughes and Young, 1966) and we have

$$Pr_m \cong 6.9\times10^{-16} \quad (4)$$

CONCLUSION

For the fluid (air), the magnetic Reynolds number as well as the magnetic Prandtl number is very small and completely different from the values used in the results. Air cannot induce a significant magnetic field and the results presented in the paper under consideration do not have any practical value. Taking the above arguments into perspective, it is clear that the results included in the paper by Zueco and Ahmed (2010) are wrong both from a theoretical and practical point of view.

Conflict of Interest

The authors have not declared any conflict of interest.

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