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Commentary

Comment on "Steady mixed convection stagnation-point flow of upper convected Maxwell fluids with magnetic field" [International Journal of non-linear mechanics, 44(2009):1048-1055]

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In the present comment, we point out a major flow found in the paper "Steady mixed convection stagnation-point flow of upper convected Maxwell fluids with magnetic field" [International Journal of non-linear mechanics, 44(2009):1048-1055].

Key words: Induced magnetic field, visco-elastic fluid, magnetic Reynold number.

ANALYSIS

In the paper above (Kumari and Nath, 2009), the steady mixed convection flow of viscoelastic fluids which obey the upper-convected Maxwell (UCM) model in the stagnation-point region of a two-dimensional body with strong applied magnetic field have been studied. Results have been presented for Prandtl numbers (Pr) = 0.71, 7.0 and 0.1 which are correspond to air, water and Helium at 20°C, respectively, and the whole work is devoted to air and water. However, there is a serious disadvantage in this paper and the present results do not have any practical value.

A new thing in the work (Kumari and Nath, 2009), is the assumption that, except for the applied external uniform magnetic field, the electrically conducting fluid induces a new magnetic field which interacts with the applied external magnetic field. However, the importance of the induced magnetic field depends on the magnetic Reynolds number which is defined as follows (Davidson, 2006):

$$R_m = \mu \sigma u l, \tag{1}$$

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. If the magnetic Reynolds number is much smaller than unity ($R_m << 1$) then 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 ($R_m >> 1$) the induced magnetic field is important and should be taken into account.

Kumari and Nath (2009) took into account the induced magnetic field without any reference to the magnetic Reynolds number which is the suitable criterion. 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

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

Let us calculate here R_m for water at 20°C. Water electrical conductivity at 20°C is $10^{-4}\ \Omega^{-1}\ m^{-1}$, (Pashley et al., 2005; Aylward and Findlay, 1994), whereas water magnetic permeability is $1.257*10^{-6}$ Vs/Am (Magnabosco et al., 2006). For a typical velocity u = 1 m/s and a typical length scale l=0.1 m, the magnetic Reynolds number (dimensionless) is

$$R_m \cong 1.257 * 10^{-11} \quad (3)$$

Instead of using the above magnetic Reynolds number, the author used the parameter α_1 named as reciprocal of magnetic Prandtl number (dimensionless),

$$\alpha_1 = (\sigma \mu_e \nu)^{-1} \quad (4)$$

where, σ is the fluid electrical conductivity, μ_e is the magnetic permeability ν is the fluid kinematic viscosity.

In the work Kumari and Nath (2009), all the presented results are corresponding to α_1 = 10 that is, magnetic Prandtl number (P_m) = 0.1 (Kumari and Nath, 2009; α_1 = 1, 10, 20, 50, 100). Let us calculate the magnetic Prandtl number (P_m) for air at 20°C. The air kinematic viscosity at 20°C is $1.827*10^{-5}$ m^2/s (Hughes and Young, 1996) and we have

$$P_m \cong 6.9*10^{-16} \quad (5)$$

Let us calculate the P_m for water at 20°C. The water kinematic viscosity at 20°C is $9.8*10^{-7}$ m^2/s, (Hughes et al., 1996) and we have

$$P_m \cong 1.23*10^{-16} \quad (6)$$

In conclusion, for the used fluids, 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 and water cannot induce a significant magnetic field and the results presented in the paper do not have any practical value.

REFERENCES

Aylward G, Findlay T (1994). SI Chemical Data, 3rd ed.; J. Wiley: New York.

Davidson PA (2006). An Introduction to Magnetohydrodynamics. Cambridge University Press, Cambridge.

Hughes WF, Young FJ (1966). The electromagnetodynamics of fluids. John Willey and Sons, New York.

Knaepen B, Kassios S, Carati D (2003). MHD turbulence at moderate magnetic Reynolds number, Center for Turbulence Research. Ann. Res. Briefs pp. 449-460.

Kumari M, Nath G (2009). Steady mixed convection stagnation-point flow of upper convected Maxwell fluids with magnetic field. Int. J. Non-Linear Mech. 44:1048-1055.

Magnabosco I, Ferro P, Tiziani A, Bonollo F (2006). Induction heat treatment of a ISO C45 steel bar: Experimental and numerical analysis. Comput. Mater. Sci. 35:98-106.

Pashley RM, Rzechowicz ML, Pashley R, Francis MJ (2005). De-Gassed Water is a Better Cleaning Agent. J. Phys. Chem. B. 109: 1231.

Pawar SD, Murugavel P, Lal DM (2009). Effect of relative humidity and sea level pressure on electrical conductivity of air over Indian Ocean. Journal of Geophysical Research. 114: D02205. Bibcode 2009JGRD..11402205P. doi:10.1029/2007JD009716.