Journal of Naval Architecture and Marine Engineering
June, 2012
DOI: 10.3329/jname.v9i1.10579
http://www.banglajol.info

TECHNICAL NOTE

COMMENT ON "INDUCED MAGNETIC FIELD WITH RADIATING FLUID OVER A POROUS VERTICAL PLATE: ANALYTICAL STUDY" AUTHORED BY SAHIN AHMED

Bhupendra Kumar Sharma

Department of Mathematics, Birla Institute of Technology and Science, Pilani, Rajasthan, India
E-mail: bhupen_1402@yahoo.co.in

In the paper with above title (Ahmed, 2010), the steady MHD heat and mass transfer by mixed convection flow of a viscous, incompressible, electrically-conducting, Newtonian fluid over a vertical porous plate taking into account the induced magnetic field has been studied. Results have been presented for air and water at 20°C with Prandtl numbers of 0.71 and 7, respectively, and the whole work is devoted to air and water. The above work is interesting but has serious disadvantage which is analyzed as follows:

(1) In Page 64, it is mentioned that "The Eckert number, Ec, is small" and in Page 67, "by adding a small term (Eckert number in this work) to" is mentioned. However, this parameter has not been defined anywhere in the paper. Usually this parameter occurs when the viscous dissipation term is included in the energy equation. However, in the present problem, no viscous dissipation term exists. This is a serious error.

(2) The important new thing in this work 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)

$$R_m = \mu\sigma ul \tag{1}$$

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. When the magnetic Reynolds number is much smaller than unity ($R_m << 1$) 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 ($R_m >> 1$) 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 author 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:

$$R_m \cong 3.8*\ 10^{-22}.$$

Received on: May 2012

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:

$$R_m \cong 1.257*\ 10^{-11}.$$

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

$$\Pr_m = \sigma\mu\nu\ , \tag{2}$$

where, ν is the fluid kinematic viscosity. All the presented results are for air and water, corresponding to Pr_m =0.1 to 0.6(Fig.: 3-9), and Pr_m =1 to 6(Fig. 10).

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:

$$Pr_m \cong 6.9*10^{-16}\ .$$

Let us calculate the Pr_m for water at 20 °C. The water kinematic viscosity at 20 °C is $9.8*10^{-7}\ m^2/s$ (Hughes and Young, 1966) and we have:

$$Pr_m \cong 1.23*10^{-16}.$$

In conclusion, for both 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 above paper do not have any practical value.

References:

Ahmed, S. (2010): Induced magnetic field with radiating fluid over a porous vertical plate: analytical study, Journal of Naval Architecture and Marine Engineering, Vol. 7, pp. 83-94.

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

Davidson, P. A. (2006): An Introduction to Magnetohydrodynamics, Cambridge University Press, Cambridge.

Hughes, W. F. and Young, F. J.(1966): The electromagnetodynamics of fluids, John Willey and Sons, New York.

Knaepen, B., Kassios, S. and Carati, D.(2003): MHD turbulence at moderate magnetic Reynolds number, Center for Turbulence Research, Annual Research Briefs, pp. 449-460.
Magnabosco, I., Ferro, P., Tiziani, A. and Bonollo, F. (2006): Induction heat treatment of a ISO C45 steel bar: Experimental and numerical analysis, Computational Materials Science, Vol. 35, pp. 98–106.

http://dx.doi.org/10.1016/j.commatsci.2005.03.010
Pashley, R. M., Rzechowicz, M. L., Pashley, R. and Francis,M. J.(2005): De-Gassed Water Is a Better Cleaning Agent, J. Phys. Chem. B, Vol. 109, pp. 1231-1238. http://dx.doi.org/10.1021/jp045975a

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