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International Journal of Thermal Sciences 48 (2009) 847–848
International Journal of Thermal Sciences
www.elsevier.com/locate/ijts

Comment on "Effects of chemical reaction on free convective flow of a polar fluid through a porous medium in the presence of internal heat generation" by Patil and Kulkarni, Int. J. Thermal Sci. 47 (2008) 1043–1054

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Received 1 March 2008; received in revised form 21 July 2008; accepted 21 July 2008

Available online 19 August 2008

Abstract

In this Letter we show that the paper by Patil and Kulkarni [P.M. Patil, P.S. Kulkarni, Effects of chemical reaction on free convective flow of a polar fluid through a porous medium in the presence of internal heat generation, Int. J. Thermal Sci. 47 (2008) 1043–1054] contains two errors which render their conclusions invalid. The first of these is a simple sign error. But the second involves the omission of part of the viscous dissipation term. We also show that the inclusion of this term yields an equation for the temperature field which cannot satisfy both the imposed boundary conditions.

Keywords: Boundary layer; Viscous dissipation

1. Analysis

In a very recent paper, Patil and Kulkarni [7], hereinafter referred to as PK2008, have studied the combined effect of surface suction and viscous dissipation on free convection induced by a uniformly hot vertical surface bounding an otherwise cold porous medium. The presence of uniform suction causes the boundary layer to have a uniform thickness, and therefore the boundary layer equations reduce to an ordinary differential system with y, the horizontal coordinate, being the independent variable. The viscous dissipative terms are assumed to be of small magnitude, so that their effect may be determined analytically using a straightforward, if lengthy, perturbation series.

The porous medium is subject to chemical reaction, which is modelled as a sink term in Eq. (5) of PK2008, which is the equation for the conservation of species. On the other hand, viscous dissipation is modelled as a source term in Eq. (4) of PK2008, which is the heat transport equation. These respective terms, by their nature, have opposite signs. However, after nondimensionalisation, the terms may be seen to have the same sign; see Eqs. (12) and (11), respectively. It is the heat transport equation which is in error, and therefore the leading term in its solution, as given in Eq. (28) of PK2008, is incorrect. Clearly subsequent terms in the expansion in E are also incorrect.

However, the authors have also omitted one term from their expression for the heat generated by viscous dissipation in their Eq. (4), by neglecting the suction flow into the heated surface. Consequently, Eq. (11) of PK2008 should be replaced by

$$\Theta'' + Pr\Theta' + Pr\,Q\Theta = -PrE\left[u'^2 + \frac{u^2}{K} + \frac{v^2}{K}\right] \tag{1}$$

where the sign error in the third term has been corrected. In the large-y limit, it is expected that $\Theta \to 0$ and $u \to 0$, but v is a nonzero suction velocity. Therefore the large-y limit of the above equation yields zero on the left-hand side and a nonzero constant on the right-hand side. In other words, it is impossible to solve this equation subject to the given boundary conditions.

Such a situation has been encountered very recently, where a forced convective flow past a uniformly hot surface bounding a porous medium was considered by Aydin and Kaya [1]. In this paper the correct viscous dissipation term was given, but account was not taken of the far-field effect of viscous dissipa-

DOI of original article: 10.1016/j.ijthermalsci.2007.07.013.

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doi:10.1016/j.ijthermalsci.2008.07.008

tion in forced convective flow in a semi-infinite domain. Further details may be found in the paper by Rees and Magyari [8], the reply by Aydin and Kaya [2], the further comments by Nield [6] and a reply to those by Aydin and Kaya [3]. We also note that this issue was discussed earlier in the review chapter of Magyari et al. [5, §9.5.1] and in the comments by Magyari et al. [4] on the paper by Tashtoush [9].

In the present situation we would like to state that, when chemical reaction, heat generation and buoyancy are neglected, then the presence of the uniform suction through a uniform temperature surface in the presence of viscous dissipation yields a bulk temperature field which decreases linearly with distance from the surface (i.e. it increases towards the heated surface). Thus, when chemical reaction and buoyancy are re-introduced, it is clear that the setting of $\Theta \to 0$ as the far-field boundary condition is incompatible with the true physics of the situation.

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