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COMMENT ON THE PAPER "COMBINED BODY FORCE AND FORCED CONVECTION IN LAMINAR FILM CONDENSATION OF MIXED VAPOURS—INTEGRAL AND FINITE DIFFERENCE TREATMENT"

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BY MEANS of the coordinate transformation [1] for the vapour boundary layer

$$\xi = \frac{g^* x}{u_\infty^2} \qquad \eta = \left(\frac{u_\infty}{\nu_r x}\right)^{1/2} \int_0^y \left(\frac{\rho}{\rho_r}\right) \mathrm{d}y \tag{1}$$

the momentum equation in physical coordinates

$$\rho\left(u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}\right) = -\frac{\partial \tau}{\partial y} + g^*(\rho - \rho_\infty) \tag{2}$$

reads in dimensionless coordinates [2]

$$\xi\left(\frac{\partial f}{\partial \eta}\frac{\partial}{\partial \xi}\frac{\partial f}{\partial \eta} - \frac{\partial f}{\partial \xi}\frac{\partial^2 f}{\partial \eta^2}\right) - \frac{1}{2} f \frac{\partial^2 f}{\partial \eta^2} = \frac{\partial}{\partial \eta}\left(\frac{\mu\rho}{\mu_r \rho_r}\frac{\partial^2 f}{\partial \eta^2}\right) + \xi\left(1 - \frac{\rho_\infty}{\rho}\right). \tag{3}$$

Corresponding transformed equations hold for the energy and the species concentration.

Concerning the new coordinates ξ and η that state the generation of overall solutions [1], some questions arise from the finite difference treatment of the partial differential equations. The following statements take into consideration the momentum equations, however, the statements are also valid for the energy and species concentration.

For a horizontal flat plate, which means $g^* = 0$, the transformation (1) leads to $\xi = 0$. Thus, no coordinate streamwise exists in the transformed plane for any arbitrary value of x. Due to Lucas [2], $\xi = 0$ represents the case of similar solution. However, according to the standard knowledge [3] the case of similar solution is characterized by a coordinate ξ, while f and f' as well as the flow field variables T and y_1 are independent of the coordinate ξ, including the boundary values. Furthermore, the coefficients of the partial differential equations, such as $\mu\rho/\mu_r\rho_r$ in equation (3), may not vary due to a variation of the streamwise coordinate ξ. As the publication by Tamir, Taitel and Schlünder [4] clearly demonstrates the general flow field exhibits—even under the assumption of constant properties—nonsimilar solutions. These results show that, as an approximation, similar solutions of the boundary layer equations may practically be applicable for the entrance region, only.

For the case of free convection, the free stream velocity becomes $u_\infty = 0$. Excluding the leading edge, the transformed coordinates (1) reduce to $\xi = \infty$, $\eta = 0$. This means that the whole flow field in the transformed $\xi - \eta$ plane will be represented by a single point. The partial differential equation (3) as well as the corresponding equations for energy and species can consequently not be approximated by finite-differences. The author has obtained a system of ordinary differential equations as he would have us believe [1] and its solution by finite-difference method for this limiting case of pure body force convection. As in the previous case for forced convection, these ordinary differential equations are said to result in similar solutions for the flow field. The investigation of the same model by Denny and Mills [5] cited by the author, exhibits, in contrast, non-similar solutions. They solved the complete system of partial differential equations without any restrictions arising from similarity requirements.

Using the finite difference method for the solution of the partial differential equations, the $\xi - \eta$ transformation (1) does not account for the limiting cases of forced convection along a flat plate and for free convection on vertical walls. This problem stems from the fact that the free-forced convection parameter xg^*/u_∞^2, a local reciprocal Froude number, is more likely an independent parameter and certainly less likely an appropriate tool for such an overall coordinate transformation. Jacobs [6] and Acrivos [7] do use a similar transformation, solely however, for the integral treatment of combined body force and forced convection flows, where the problems discussed in the previous sections, do not arise.

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