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LETTER TO THE EDITORS

A NOTE ON THE NUMERICAL SOLUTION OF FREE CONVECTION IN OPEN ENDED VERTICAL CHANNELS

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WE HAVE read with interest two recent papers in the Journal on free convection between asymmetrically heated parallel plates. The first paper by W. Aung [1] was published in August, 1972, and dealt with the developed flow case and this was followed in the November issue with a second paper by W. Aung, L. S. Fletcher and V. Sernas [2] for the developing flow situation.

We are particularly interested in the results of the latter work which included a numerical analysis of the pertinent conservation equations for the case of a fluid with Prandtl number = 0·7. In our approach to this problem, we are using different forms of the conservation equations. In particular, a second order continuity equation:

$$\frac{\partial^2 u}{\partial x \partial y} + \frac{\partial^2 v}{\partial y^2} = 0 \qquad (1)$$

is employed in place of the more usual first order equation, from which Aung *et al.* [2] obtain their transverse velocities. There is a special reason for equation (1). In the solution, it is necessary to use (in addition to the conservation equations) the integral continuity equation to meet the deficiency in boundary conditions. Ogunba [3] has reasoned in a convincing manner that since the first order equation and the integral equation are not mathematically independent, then the solution for the transverse velocity from the former need not be unique. Indeed there is evidence to show that many authors have found random values of the transverse velocities in problems of this type and perhaps they have unwittingly attributed this to errors in numerical computation rather than lack of rigour in formulating the mathematical equations. It is to be noticed that Aung *et al.* [2], do not indicate the magnitude and distribution of their transverse velocities and in view of our experience we would be interested to know if they found difficulty in obtaining meaningful results. Of course, the calculation of the transverse velocity is not very important in the present problem, but sensible values lend support to the reliability of the method of computation.

On a further point concerning the determination of the flow rate, Aung *et al.* [2], select a flow rate and determine the channel length for which the pressure defect at exit is zero. This procedure is necessary because the flow rate is interdependent with the heat transfer to the flow. In our study, we have adopted the method of selecting the channel length (since this may be already fixed in a design problem) and then iterate on the flow rate to obtain that which satisfies the end pressure condition. There should of course be no difference in the result, and which procedure is adopted is a matter of choice.

We look forward with interest to the comments of Aung, Fletcher and V. Sernas on our observations on their paper which makes a useful contribution in the field of free convection in ducts which are open ended.

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REFERENCES

1. W. AUNG, Fully developed laminar free convection between vertical plates heated asymmetrically, *Int. J. Heat Mass Transfer* **15** 1577 (1972).
2. W. AUNG, L. S. FLETCHER and V. SERNAS, Developing laminar free convection between vertical flat plates with asymmetric heating, *Int. J. Heat Mass Transfer* **15**, 2293 (1972).
3. V. OGUNBA, Mixed convection in the entry region of an internally heated concentric annulus in upward flow, Ph.D. Thesis, University of Liverpool (1972).