Readers' Forum

Brief discussions of previous investigations in the aerospace sciences and technical comments on papers published in the AIAA Journal *are presented in this special department. Entries must be restricted to a maximum of 1000 words, or the equivalent of one* Journal *page including formulas and figures. A Discussion will be published as quickly as possible after receipt of the manuscript. Neither the AIAA nor its editors are responsible for the opinions expressed by the correspondents. Authors will be invited to reply promptly.*

Comment on "Navier-Stokes Similarity Solution for the Planar Liquid Wall Jet"

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THE author of Ref. 1 has tried but failed to solve the classical problem that was presented by Batchelor.[2] First, Eq. (7) in Ref. 1 is the same equation (5.6.2) given in Ref. 2 where $F = \nu Rf$. The boundary conditions for Eq. (7) are $f(0) = 1$, $f'(0) = 0$, and $f(\pm\alpha) = 0$, where α is the angle between the channel wall and the plane of symmetry of the channel. This problem can be solved numerically by means of the Runge-Kutta methods and by transforming the boundary-value problem to the initial-value problem where some values of $f''(0)$ are shown in Fig. 1. It is apparent from this figure that the value of $f''(0)$ is a function of both parameters, R and α. When $R \geqq 10$ and $\alpha = 1$, no solution for purely divergent flow is obtainable. Likewise, no purely divergent flow exists when $R \geq 25$ and $\alpha = 0.6$. Typical velocity profiles for various αR where $\alpha = 0.785$ are shown in Fig. 2. A pending compound flow can be observed for $\alpha R = 11.775$ in the figure. Therefore, there will be no purely divergent flow for $R > 15$ and $\alpha = 0.785$.

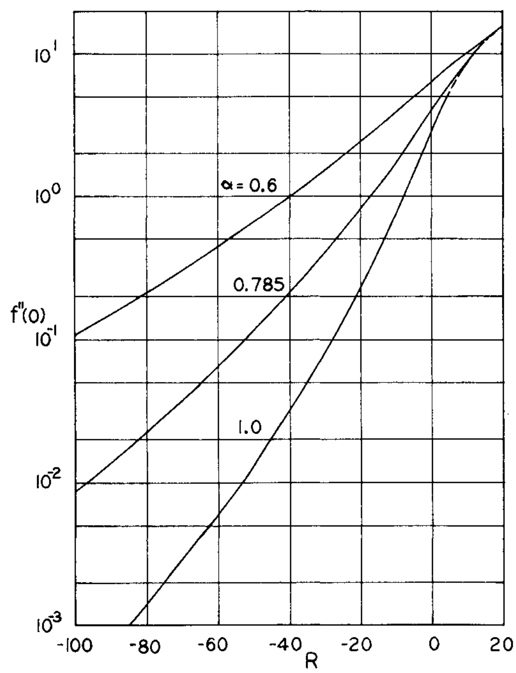

Fig. 1 Initial values $f''(0)$ for purely convergent or purely divergent flows at various channel half-angles and Reynolds numbers.

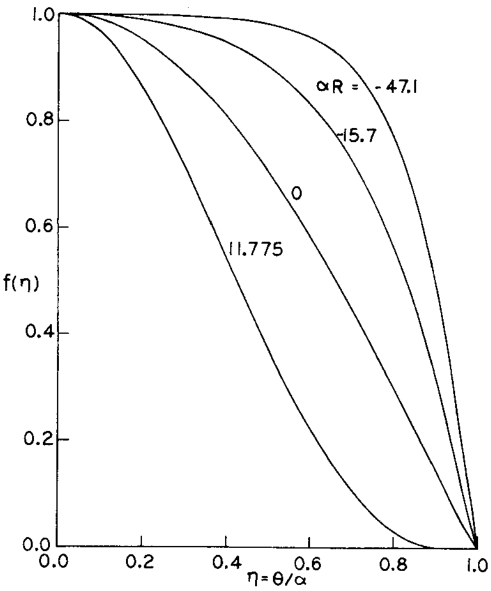

Fig. 2 Radial velocity distributions in a convergent or divergent channel for $\alpha = 0.785$.

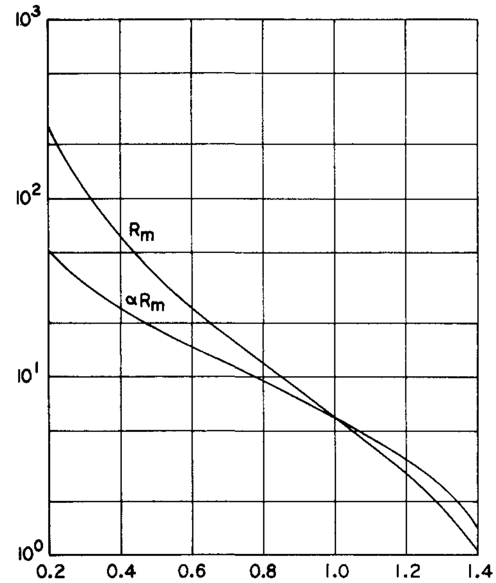

Fig. 3 The maximum Reynolds number for purely divergent flows at various channel half-angle α.

It was presented in Ref. 1 that $f''(0) = -(4+R)$. When these values of $f''(0)$ along with the other initial values are used to integrate Eq. (7) numerically, it will result in a violation of the boundary condition that $f(\pm\alpha) = 0$. In other words, the value of $f(\pm\alpha)$ is not negligible, i.e., it is equal to -0.0444 and 1.0 for $R = 30$ and -4, respectively. The latter case yields an impossible uniform flow throughout the channel. All these facts imply the invalidity of Eqs. (9), (10), and (11). Therefore, Figs. 2–4 in Ref. 1 do not represent solutions

Received Feb. 9, 1987.

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for Eq. (7) and minimum value of R is not limited to -4, as evidenced in Figs. 1 and 2 of this Comment. Furthermore, for $\alpha=1$ and $R=-200$, a purely convergent flow exists with $f''(0)=-2.193\times10^{-6}$.

Figure 3 shows the relation between α and the maximum value of R, namely R_m, for which a purely divergent flow is possible. For $\alpha\geq1$, the value of R_m in Ref. 2 is a bit too large so that the value of $f'(\pm\alpha)$ is positive, implying the commencement of a compound flow. For $\alpha<1$, the value of R_m in Ref. 2 is not really the maximum value because the value of $f'(\pm\alpha)$ is still much less than zero. For example, the value of $f'(\pm\alpha)$ is equal to -0.3886 for $\alpha=0.785$ and $R=10$ which is the R_m in Ref. 2. The R_m for this angle should be 12.6 which yields $f'(\pm\alpha)=-0.00414$. When R is increased to 12.7 it yields $+0.01157$, indicating a compound flow. Although it is correct that the value of R_m approaches zero as α is increased to $\pi/2$, the value of αR_m is not nearly constant.

References

[1]Rubel, A., "Navier-Stokes Similarity Solution for the Planar Liquid Wall Jet," *AIAA Journal*, Vol. 25, Jan. 1987, pp. 179–181.

[2]Batchelor, G. K., *An Introduction to Fluid Dynamics*, Cambridge University Press, Cambridge, 1967, pp. 294–302.

Reply by Author to H. Chuang

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PROFESSOR Chuang seems to have little idea of the content of Ref. 1. In that work, a subset of the classical channel flow problem (e.g., Batchelor[2]) was shown to have particular significance to the planar liquid wall jet problem. In fact, the two problems satisfy the same third-order differential equation and share three common boundary conditions. This seems to have bewildered Chuang to the point that he has recomputed the channel flows of Ref. 2 and offers them as commentary. The contribution of Ref. 1 is the discovery that the normal stress balance at the liquid wall jet interface introduces a new constraint reducing the two parameter (α,R) family of classical solutions to a one parameter family of wall jet solutions. That is, for each wall angle α, there is a single Reynolds number R for which the interface condition is satisfied. All other solutions that Chuang's computer code spews are of absolutely no significance to the wall jet problem.

References

[1]Rubel, A., "Navier-Stokes Similarity Solution for the Planar Liquid Wall Jet," *AIAA Journal*, Vol. 25, Jan. 1987, pp. 179–181.

[2]Batchelor, G. K., *An Introduction to Fluid Dynamics*, Cambridge University Press, Cambridge, 1967, pp. 294–302.

Submitted Feb. 25, 1987.

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Comment on "Computation of Second-Order Accurate Unsteady Aerodynamic Generalized Forces"

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REFERENCE 1 presents no new information. In fact, a Note by the present author,[2] covering the same subject, was published over 20 years ago. Furthermore, no reference was given to this Note.

The author of the above article[1] in his Conclusions states, "adapting existing kernel function codes using collocation (for applying the method proposed) is straightforward. The integrations reduce to special weighted sums of the downwash at the control stations, which adds little computational load to these with substantial improvements in convergence" (note: the parenthetical statement is mine). The present author agrees that the accuracy may be improved in that way, but cannot see that the additional computational load would be small in practical flutter cases where a square aerodynamic matrix is needed. The calculation for any control station would be the same as for any ordinary collocation point. It was stated in my Note[2] that most collocation methods employed optimal collocation points, which implies that they already were second-order accurate for regular modes.

Because of advantages gained for control-surfaces oscillating in rotation about their leading edges and for wings with unswept trailing edges, the reverse-flow theorem was used earlier on by this author for planar wings[3,4] as well as for a T-tail.[5] The numerical method employed in these cases could have been made more efficient and competitive by using the advanced velocity potential[6] instead of the integrated acceleration potential[7]. The property of the kernel, being dependent only on the difference between control point and integration point coordinates is preserved so that corresponding influence coefficients become general and applicable for different planforms.

References

[1]Niekerk, B. van, "Computation of Second-Order Accurate Unsteady Aerodynamic Generalized Forces," *AIAA Journal*, Vol. 24, March 1986, pp. 492–498.

[2]Stark, V. J. E., "On the Approximation of the Normal Velocity on Oscillating Wings," *AIAA Journal*, Vol. 4, Dec. 1966, pp. 2236–2239.

[3]Stark, V. J. E., "A Method for Solving the Subsonic Problem of the Oscillating Finite Wing with the Aid of High-speed Digital Computers," Saab Aircraft Co., Sweden, TN 41, 1958.

[4]Stark, V. J. E., "Aerodynamic Forces on Rectangular Wings Oscillating in Subsonic Flow," Saab Aircraft Co., TN 44, 1960.

[5]Stark, V. J. E., "Aerodynamic Forces on a Combination of a Wing and a Fin Oscillating in Subsonic Flow," Saab Aircraft Co., TN 54, 1964.

[6]Stark, V. J. E., "Application to the Viggen Aircraft Configuration of the Polar Coordinate Method for Unsteady Subsonic Flows," ICAS Paper 74-03, Aug. 1974.

[7]Landahl, M. T. and Stark, V. J. E., "Numerical Lifting-Surface Theory—Problems and Progress," *AIAA Journal*, Vol. 6, Nov. 1968, pp. 2049–2060.

Received Aug 4, 1986.

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