Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
European Journal of Mechanics B/Fluids 24 (2005) 788–790
EUROPEAN JOURNAL OF MECHANICS B/FLUIDS

Erratum

Erratum to "Axisymmetric stagnation flow obliquely impinging on a circular cylinder" [Eur. J. Mech. B/Fluids 22 (2) (2003) 123–131]

Patrick D. Weidman [a,*], Vakhtang Putkaradze [b]

[a] *Department of Mechanical Engineering, University of Colorado, Boulder, CO 80309-0427, USA*
[b] *Department of Mathematics and Statistics, University of New Mexico, Albuquerque, NM 87131-1141, USA*

Received 10 February 2005; accepted 20 April 2005

Available online 17 May 2005

In compiling papers on exact solutions of the Navier Stokes equations for publication in a book with the late Philip Drazin, Professor Norman Riley of the University of East Anglia has pointed out an egregious error in our study that we wish to correct forthwith. In this Erratum, we adhere to the same numbering for equations, figures and references found in our original manuscript.

The problem lies in the computation of the outer pressure field $p_1(r,z)$ to which the near field viscous solution must match as $z \to \infty$. We were misled by the fact that in the planar oblique stagnation flow studied by Stuart [3], Tamada [4] and Dorrepaal [5] there is no viscous correction to the outer pressure field, i.e., the uniform shear term added to the outer potential stagnation flow cancels exactly in the viscous term of the Navier Stokes equations. This is not the case, however, in axisymmetric stagnation flow impinging on a circular cylinder and we must replace "Euler equations" by "Navier Stokes equations" in the sentence preceding Eq. (2.7), which itself now reads:

$$p_1(r,z) = -R\left[\frac{1}{2}\left(r - \frac{1}{r}\right)^2 + 2z^2\right] + 2\gamma z + const. \tag{2.7}$$

and hence Eq. (2.10c) becomes:

$$p(\eta,z) = -R\left[\frac{1}{2}\frac{(\eta-1)^2}{\eta} + 2z^2\right] + 2\gamma z + const. \tag{2.10c}$$

Matching the viscous pressure field to this corrected outer pressure, with its additional term linear in z, modifies our subsequent pressure terms, our large-R asymptotics, and the results plotted in Figs. 3, 4 and 5.

Eq. (2.13b) and the paragraph encompassing (2.14) should read:

$$-\frac{\partial p}{\partial z} = 4Rz - 2\gamma B. \tag{2.13b}$$

Matching the axial pressure gradient given in (2.13b) with its far-field counterpart calculated from (2.10c) gives $B = -1$. Hence the pressure distribution for the oblique stagnation flow found from integration of (2.13) is given by

$$p(\eta,z) = -R\left(\frac{f^2}{2\eta} + 2z^2\right) + f' + 2\gamma z + const. \tag{2.14}$$

DOI of original article: 10.1016/S0997-7546(03)00019-0.
* Corresponding author.
E-mail address: weidman@colorado.edu (P.D. Weidman).

0997-7546/$ – see front matter
doi:10.1016/j.euromechflu.2005.04.001

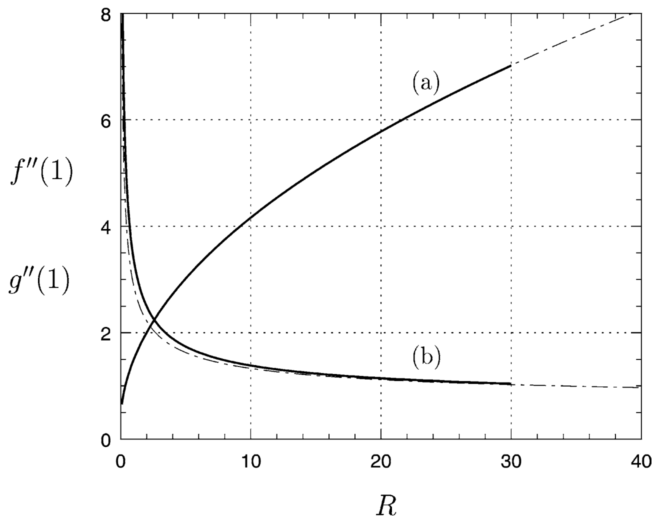

Fig. 3. Shear stress parameters (a) $f''(1)$ and (b) $g''(1)$ as a function of R showing both the numerical values (solid curves) and the two-term asymptotic approximations (dashed curves) computed using (3.5a,b).

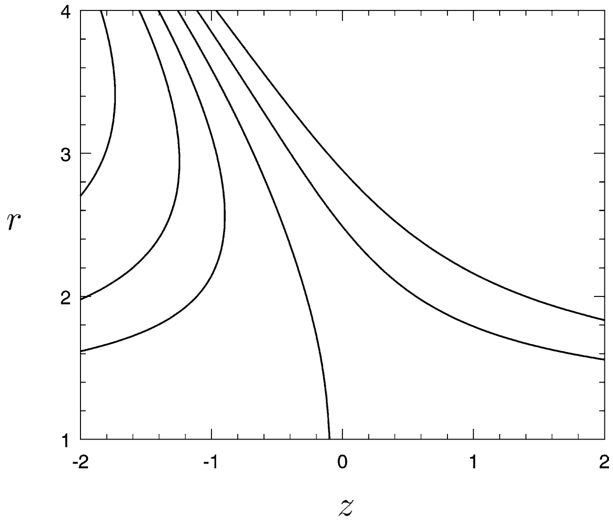

Fig. 4. Streamline pattern for $R = 20$ and $\gamma = 1$; ψ varies from -2.0 to 2.0 in increments of 0.5.

Note that, in contrast to planar oblique stagnation flow, the pressure field is altered by the γ-component of the axial flow in (2.9b).

Finally in this section one needs to modify the last two sentences that include the asymptotic formula for $g'(\eta)$ in Eq. (2.17) as follows:

The linear equation governing the asymptotic behavior of $g(\eta)$ is obtained by inserting (2.15) and its derivative into (2.11b) with $B = -1$. The asymptotic behavior for $g'(\eta)$ has the form

$$g'(\eta) \sim \left[(\eta - 1) - \eta_0\right] + \frac{2}{R} + \text{E.S.T.} \quad (\eta \to \infty). \tag{2.17}$$

In Section 3 for the large-R asymptotics we make the following corrections to Eqs. (3.1b) and (3.3b):

$$(1 + \epsilon\xi)G''' + \epsilon G'' + (FG'' - F'G') = -\epsilon; \quad G(0) = G'(0) = 0, \quad G''(\infty) \to 1. \tag{3.1b}$$

$$G_1''' + \xi G_0''' + G_0''(1 + F_1) + F_0 G_1'' - F_0' G_1' - G_0' F_1' = -1. \tag{3.3b}$$

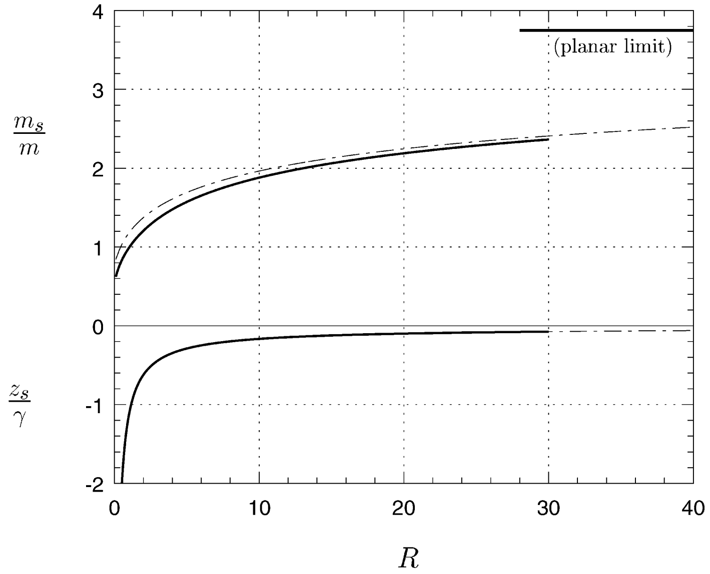

Fig. 6. Values m_s/m and z_s/γ as a function of R showing both the numerical values (solid curves) and asymptotic approximations (dashed curves) computed using (4.5) with asymptotic results (3.5a,b) inserted therein. Also shown is the planar limit $m_s/m = 3.74851$ to which the present results tend as $R \to \infty$.

Integration of (3.13b) leads to the corrected value $G_1''(0) = 2.8005$ in which case Eq. (3.5b) becomes

$$g''(1) \sim 0.60795 + 2.8005\, R^{-1/2}. \tag{3.5b}$$

In Section 4 for the presentation of results, the paragraph including Eqs. (4.5) and (4.6) are corrected to:

Two-term asymptotic behaviors for z_s and m_s/m in (4.2) and (4.5) calculated using (3.5a,b) are

$$z_s \sim -\left(0.24662R^{-1/2} + 0.87022R^{-1}\right)\gamma \tag{4.6}$$

and

$$\frac{m_s}{m} \sim 3.74851 - 3.30692R^{-1/2}. \tag{4.7}$$

A comparison of these results with exact numerical calculations is given in Fig. 6. Note the slow convergence of m_s/m to the planar limit 3.74851 found by Dorrepaal [5]; to arrive within 1% of this limit one would need $R \sim 6{,}700$ in (4.7).

We note that the above corrections do not affect our comparison with the results of Dorrepaal [5,6] in the body of the text and in the Appendix.

Acknowledgements

The authors are indebted to Professor Norman Riley for pointing out the error in our paper.

References

[3] J.T. Stuart, The viscous flow near a stagnation point when the external flow has uniform vorticity, J. Aero/Space Sci. 26 (1959) 124–125.
[4] K. Tamada, Two-dimensional stagnation-point flow impinging obliquely on a plane wall, J. Phys. Soc. Japan 46 (1979) 310–311.
[5] J.M. Dorrepaal, An exact solution of the Navier–Stokes equation which describes non-orthogonal stagnation-point flow in two dimensions, J. Fluid Mech. 163 (1986) 141–147.
[6] J.M. Dorrepaal, Is two-dimensional oblique stagnation-point flow unique?, Canadian Appl. Math. Quart. 8 (2000) 61–66.