In addition to the static and oscillatory cases, Ref. 2 also considers the transient case. The simplicity of slender-body theory permits the definition of a series of transient AICs from which the control-point forces can be found in terms of the control-point deflections and their first two derivatives:

$$\{F(t)\} = (qS/\bar{c})([C_{hs}]\{h\} + [C_{hd}]\{\dot{h}\bar{c}/V\} + [C_{hi}]\{\ddot{h}\bar{c}^2/V^2\})$$

The option for the transient case in the computer program of Ref. 2 generates the static AICs $[C_{hs}]$, the damping AICs $[C_{hd}]$, and the inertial AICs $[C_{hi}]$.

References

[1] Rodden, W. P. and Revell, J. D., "The status of unsteady aerodynamic influence coefficients," Inst. Aerospace Sci. Paper FF-33 (January 1962).

[2] Rodden, W. P., Farkas, E. F., and Takata, G. Y., "Aerodynamic influence coefficients from slender body theory: analytical development and computational procedure," Aerospace Corp. Rept. TDR-169 (3230-11) TN-6 (October 31, 1962).

Comments on "Angle of Attack and Sideslip from Pressure Measurements on a Fixed Hemispherical Nose"

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KEENER[1] calls attention to "a simple method for sensing angle of attack and sideslip that appears to have been overlooked in the design of flow-direction probes." The writer, in a study conducted for the then Wright Air Development Center[2] five years ago, used a simple variant of Keener's method to normalize the pressure difference on blunt angle-of-attack, angle-of-sideslip probes. This involves the use of the pitot pressure alone (or P_{90} in Keener's notation) rather than the difference between the pitot pressure and some other surface pressure. For $M > 3$, this method has the advantage of the requiring fewer measurements and involves a simpler calibration formula. Since

$$P_{90} = P_{90\alpha=0} \cos^2\alpha \qquad (1)$$

on a hemisphere for these conditions, the calibration formula becomes

$$\frac{P_l - P_u}{P_{90}} = \frac{\cos^2(\delta_l - \alpha) - \cos^2(\delta_u + \alpha)}{\cos^2\alpha} \qquad (2)$$

where δ_l is the angular displacement of the lower orifice measured from the pitot pressure source and δ_u is the angular displacement of the upper source. Equation (2) has the further advantage of being somewhat more linear for $\alpha < 10°$ than Keener's result. When δ_u and δ_l are 45°, for example, Eq. (2) becomes simply

$$(P_l - P_u)/P_{90} = 2 \tan\alpha \qquad (3)$$

It may be of interest to note that a similar relation has been found to give good agreement with experimental results for an angle sensor made from a spherically capped cone with a small pitot source in the nose. It also was found that, to account for the change in pressure distribution with change in Mach number, one could replace α by $\alpha/(1 + 1/M^2)$ with generally good results. This may prove to be a more direct method than that suggested by Keener, i.e., generalizing the exponent in Eqs. (1) and (2), if $\alpha > 20°$. Keener's method of using a pressure difference to normalize $p_l - p_u$ apparently makes the result insensitive to changes in M for $1.5 \leq M \leq 3$ and $\alpha < 20°$, which the present method does not.

Finally, it might be pertinent to mention that recent wind-tunnel experience has indicated that Keener's estimate of the accuracy attainable (within $\pm 1°$) may be too conservative. With carefully calibrated pressure gages of high quality, data scatter has been kept to $\pm\frac{1}{2}°$ or less in most cases.

References

[1] Keener, E. R., "Angle of attack and sideslip from pressure measurements on a fixed hemispherical nose," J. Aerospace Sci. **29**, 1129–1130 (1962).

[2] Smetana, F. O. and Headley, J. W., "A further study of angle-of-attack, angle-of-sideslip, pitot-static tubes," Wright Air Dev. Center, WADC TR 57-234 (June 1958).

Received by IAS October 31, 1962.
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Blast-Hypersonic Flow Analogy

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IN view of the recently published erratum,[1] the footnote on p. 1342 of Ref. 2 should be disregarded, Eqs. (5-8) of Ref. 2 being correct.

References

[1] Jones, D. L., "Erratum: strong blast waves in spherical, cylindrical and plane shocks," Phys. Fluids **5**, 637 (1962).

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Received by ARS December 5, 1962.
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Comment on "Heat Transfer in Planetary Atmospheres at Super-Satellite Speeds"

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Nomenclature

h = enthalpy, ft²/sec²
u_1 = velocity at outer edge boundary layer, fps
ρ_w = density, slug/ft³
$\dot{q}_w$ = stagnation point heat transfer rate, Btu/ft²-sec
μ_w = viscosity, slug/sec-ft
β = external velocity gradient, du_1/dx sec^{-1}
Nu = $[\dot{q}_w x c_{p_w}/k_w(h_0 - h_w)]$
Re_x = $u_1 x/\nu_w$

HOSHIZAKI[1] has shown that the dependence of the stagnation point heat transfer rate on flow field properties is the same both at low speeds, on the order of 5 to 10,000 fps,

Received by ARS December 6, 1962.
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and at super-satellite speeds, using a correlation in terms of the wall temperature, the product $\rho_w \mu_w \beta$, and the freestream velocity. This correlation holds not only for air but also for CO_2.

It is interesting to note that a similar dependency has been shown previously,[2, 3] where the correlation was based on the results obtained from an integral method at temperatures up to 8500°K and did not include the region of large ionization in the boundary layer. The results from this analysis were divided into two cases:

Case 1:

$$0.5 \leqslant h_w/h_0 \leqslant 1.0 \qquad Nu/Re_x^{1/2} = 0.744\ Pr_w^{0.656} \tag{1}$$

Case 2:

$$h_w/h_0 < 0.5 \qquad Nu/Re_x^{1/2} = 0.848\ Pr_w^{0.656}(h_w/h_0)^{0.154}$$

The correlation of Hoshizaki is based on results that lie mainly in the range of case 2. The expression for the heat transfer rate for case 2 which is arrived at in Ref. 2 is

$$(\dot{q}_w = 0.349 \times 10^4[(h_w)^{0.154}/(Pr_w)^{0.344}](\rho_w \mu_w \beta)^{0.5} (V_\infty/10^4)^{1.692}[1 - (h_w/h_0)] \tag{2}$$

where it is assumed that $h_0 = \frac{1}{2}V_\infty^2$. For $T_w = 520°R$ and $Pr_w = 0.72$, Eq. (2) reduces to

$$\dot{q}_w = 3.91 \times 10^4(\rho_w \mu_w \beta)^{0.5}(V_\infty/10^4)^{1.692}[1 - (h_w/h_0)] \tag{3}$$

This is almost identical with Ref. 1 except for the constant. (Hoshizaki's value for this condition is 3.88×10^4.)

It should be noted that the results of Ref. 3 indicate that the exponent on the freestream velocity is 2 for the adiabatic wall case, then gradually decreases until $h_w/h_0 = 0.5$ where the exponent is 1.692, and then remains constant as the wall becomes relatively colder.

It should be acknowledged that the results of Hoshizaki show the consistency of boundary layer behavior even when complex real gas phenomena are taking place. It is apparent also that the expressions for the basic heat transfer parameter, Eq. (1), may be extended beyond the range over which the correlation was obtained and considered a general expression. The limits on Eq. (1) may be determined experimentally only.

References

[1] Hoshizaki, H., "Heat transfer in planetary atmospheres at super-satellite speeds," ARS J. **32**, 1544–1551 (1962).

[2] Nerem, R. M., "Integral approach to stagnation point heat transfer," ARS J. **32**, 89–91 (1962).

[3] Nerem, R. M., "Stagnation point heat transfer on an axisymmetric body," Ohio State Univ. Aerodynam. Lab., Rept. ARL (Aeronaut. Research Lab.) 44 (August 1961).

Corrections and Comments on "Aerodynamic Processes in the Downwash Impingement Problem"

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IT was shown in a recent paper[1] that one mechanism causing particle entrainment in a jet impinging on the ground stemmed from the lift force on the particle. The lift force was regarded there as the sum of two components, the interference lift due to wall proximity and the lift stemming from the stream shear, and was estimated using existing theoretical solutions. The two components were found to be about equal in magnitude.

Received January 2, 1963.

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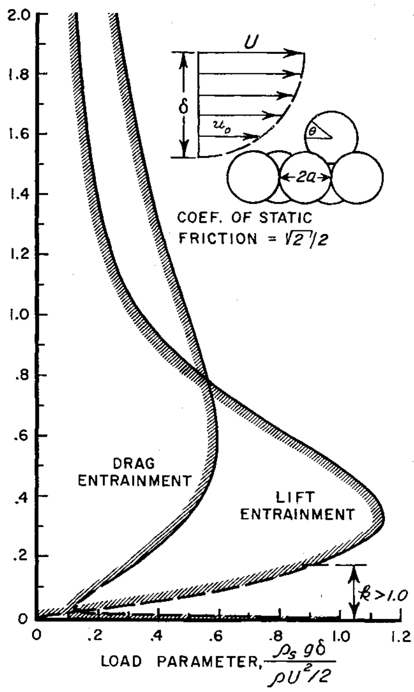

Fig. 1 Criteria for particle entrainment in an axisymmetric stagnation flow, $u/u_0 \approx R/D$

It has been brought to the author's attention that an error in sign was made in calculating the interference lift [Eq. (7) of Ref. 1],† and that the classical solutions for a sphere under the influence of a wall show that the body is attracted toward the wall. The purpose of this note is to take cognizance of that error, to show that the interference lift on a sphere close to a wall is small in comparison with the lift due to shear, and to present new criteria for particle entrainment based on more accurate estimates of the particle forces.

The classical approach in calculating the interference effects of a wall on a sphere[2, 3] is to replace the wall with an array of sphere images. An expansion procedure is employed in which the sphere radius is assumed small in comparison with the distance from the wall to the sphere center. Consequently, these solutions cease to be valid in the present problem, where the sphere is in contact with the wall.

There are experimental data[4] obtained with the sphere center 1.08 radii from a wall and with various support structures between the wall and the sphere. With no structure between the sphere and wall, the lift coefficient was −0.03. This compares with $C_L = -0.38$ predicted by interference theory.[2, 3] This measured lift due to wall interference is small in comparison with the lift due to stream shear under typical conditions, and it is concluded that the wall interference effect on lift is negligibly small in the present problem.

These results[4] demonstrate an additional lift-producing mechanism in the particle-entrainment problem which has not been considered. Data were obtained with four thin support columns between the sphere and the wall. The net result of these columns and their wakes was to eliminate almost completely the suction pressure over the enclosed area. The resulting lift coefficient (away from the wall) was 0.30. When the support columns were enclosed completely with a collar,

† The author would like to express his appreciation to E. Levinsky of the Aerospace Corporation for pointing out this error.