Technical Comments

Comment on "Unsteady Embedded Newton-Busemann Flow Theory"

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IN a recent paper, Tong and Hui[1] have misrepresented results obtained through use of the embedded Newtonian theory.[2] In Fig. 4 of Ref. 1, the embedded Newtonian theory[2] is shown to be able to predict only a fraction of the true damping characteristics. The authors conclude: "Ericsson's theory is similar to Newtonian impact theory alone and underpredicts the damping derivatives when compared with experimental data (Fig. 3)." The reader who goes back to the source for Fig. 3, which is Fig. 5 in the paper by Khalid and East[3] (the *Journal of Spacecaft and Rockets* reader can find the figure reproduced in the previous *Journal of Spacecraft and Rockets* issue as Fig. 7 of Ref. 4), must be thoroughly confused to find Ericsson's theory agreeing very well with experimental results. As a matter of fact, the agreement with the theory of Tong and Hui[1] is also very good, as is demonstrated by Fig. 1.

The comparison in Fig. 1 illustrates that the ratio between the damping derivatives of blunt and sharp cones is rather insensitive to the basic theory used. This is, of course, to be expected, as this insensitivity was one of the main reasons for introducing the blunt/sharp cone ratio as a suitable parameter when comparing inviscid theoretical predictions with viscous experimental results.[5] The difference between inviscid theory and viscous experiments is likely to be much larger than the difference between two different inviscid theories.

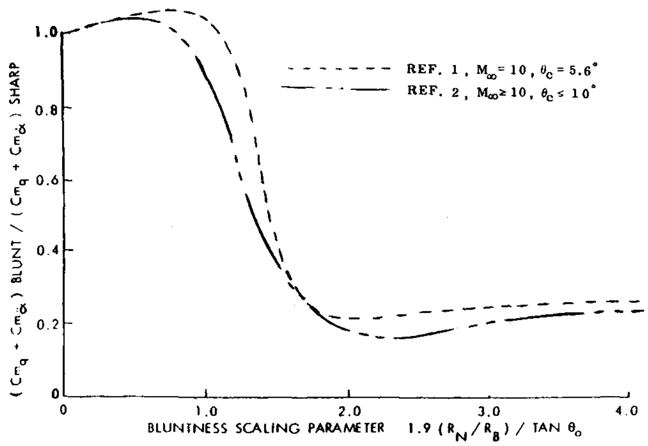

Fig. 1 Normalized damping-in-pitch derivatives vs bluntness scaling parameter for spherically blunted cones.

Tong and Hui, after making the quoted statement in Ref. 1, add, "In passing we note that Ericsson uses the sharp cone Newtonian value as the scaling factor, which is not the correct limiting value of gasdynamic theory, to show the effects of nose bluntness of the cone and obtains a similar trend [see Fig. 5 of Ref. 12 (present Ref. 3)] as in Fig. 3." The correct limiting value when letting the nose bluntness approach zero is, of course, the Newtonian impact value for the embedded Newtonian theory[2] and the Newton-Busemann value[6] for the embedded Newton-Busemann theory.[1]

Although one can obviously not switch theory while evaluating the relative effect of nose bluntness, one can use any means to determine the sharp cone value which, when combined with the normalized derivative value, will give the blunt cone stability derivative.

One fact brought out by Fig. 4 in Ref. 1 is that the Newton-Busemann theory[6] predicts a sharp cone damping derivative that is approximately twice as large as that given by Newtonian impact theory. Based on past experience by investigators when comparing experimental results with Newtonian predictions, one must conclude that the Newton-Busemann theory[6] grossly overpredicts the sharp cone damping measured experimentally. The speculation in Ref. 6 that "the Newton-Busemann theory may have overpredicted $-C_{m\dot\theta}$ by just the right amount to account for viscous effects is, of course, not realistic in view of the large effects of Reynolds and Mach number on the viscid/inviscid interaction.[7] This is particularly true in regard to experimental results obtained in ground facilities, where support interference often produces the largest viscous flow effect.[8,9] It is shown in Ref. 10 that when the Newtonian impact theory is corrected for the effect of finite Mach number and $\gamma \neq 1$, it gives predictions in good agreement with experimental results obtained at high Reynolds numbers, where the viscous flow effects are expected to be small.

References

[1]Tong, B.-G. and Hui, W.H., "Unsteady Embedded Newton-Busemann Flow Theory," *Journal of Spacecraft and Rockets,* Vol. 23, March-April 1986, p. 129-135.

[2]Ericsson, L.E., "Unsteady Embedded Newtonian Flow," *Astronautic Acta,* Vol. 18, 1973, pp. 309-330.

[3]Khalid, M. and East, R.A., "Measurements of Dynamic Stability Derivatives of Hyperballistic and Conic Shapes at $M = 6.85$," *Aeronautical Quarterly,* Vol. 32, 1981, pp. 1-30.

[4]Ericsson, L.E., "Parametric Investigations of Slender Cone Nose Bluntness Effects," *Journal of Spacecraft and Rockets,* Vol. 23, Jan.-Feb. 1986, pp. 126-128.

[5]Ericsson, L.E., "Universal Scaling Laws for Hypersonic Nose Bluntness Effects," *AIAA Journal,* Vol. 7, Dec. 1969, pp. 2222-2227.

[6]Hui, W.H. and Tobak, M., "Unsteady Newton-Busemann Flow Theory, Pt. II: Bodies of Revolution," *AIAA Journal,* Vol. 19, Oct. 1981, pp. 1272-1273; full paper available as NASA TM-80459.

[7]Ericsson, L.E., "Nonlinear Hypersonic Viscous Crossflow Effects on Slender Vehicle Dynamics," *AIAA Journal,* Vol. 17, June 1979, pp. 586-593.

[8]Ericsson, L.E. and Reding, J.P., "Viscous Interaction or Support Interference—The Dynamicists Dilemma," *AIAA Journal,* Vol. 16, April 1978, pp. 363-368.

[9]Ericsson, L.E. and Reding, J.P., "Review of Support Interference in Dynamic Tests," *AIAA Journal,* Vol. 21, Dec. 1983, pp. 1652-1666.

[10]Ericsson, L.E., "Effect of Mach Number on Slender Vehicle Dynamics," *Journal of Spacecraft and Rockets,* Vol. 18, Jan.-Feb. 1981, pp. 18-23.

Received April 18, 1986.

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