Technical Comments

Comment on "Similarity Rule Estimation Methods for Cone Flow with Variable Gamma"

TA-JIN KUO*
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, Calif.

IN a previous Technical Note, Prof. Blick and his associates[1] set out to present numerical correlations for conical flows with γ varying between 1.4 and 1.05. However, their shock-wave angle correlation

$$M_1 \sin\sigma - 1 + \cos\theta = [0.97 - 0.242(1.4 - \gamma)] \times [1 + 0.5(\gamma + 1)(\beta \sin\theta)^2]^{1/2}$$

reduces to

$$\sin\sigma/\sin\theta \simeq [0.97 - 0.242(1.4 - \gamma)] \left[\frac{(\gamma + 1)}{2}\right]^{1/2} \quad (1)$$

when

$$M_1 \sin\theta \gg 1$$

Accordingly, the shock-wave angle σ would be less than the half-cone angle whenever $\gamma < 1.2703$, the range of γ values across the shock which is of practical interest to problems of hypersonic flights. Also, for Eq. (1) to agree with the following formula numerically,

$$\sigma - \theta = (\epsilon/2) \tan\sigma, \quad \epsilon = (\gamma - 1)/(\gamma + 1)$$

which is obtainable from the constant density model or the Newtonian homogeneous layer model, γ would have to be as large as 1.465. These conclusions drawn from their shock-wave angle correlation are anomalous in the hypersonic regime.

Furthermore, their cone surface Mach number was obtained with the assumption that the γ values on both sides of the shock be identical, which is certainly not realistic if there is appreciable dissociation and/or ionization on either side of the shock front.

Thus, the assertion that their correlations may be of interest where conical bodies are flying through high-temperature nuclear blasts or through the atmosphere of the planets does not appear to be fully supported by their own findings.

Reference

[1] Blick, E. F., Walters, R. R., and Von Rosenberg, C., "Similarity Rule Estimation Methods for Cone Flow with Variable Gamma," *AIAA Journal*, Vol. 6, No. 5, May 1968, pp. 959–961.

Received September 16, 1970.

* NAS-NRC Postdoctoral Resident Research Associate.

Reply by Author to Ta-jin Kuo

E. F. BLICK*
University of Oklahoma, Norman, Okla.

KUO'S points are well taken. The shock-wave angle correlation (Eq. 5 in Ref. 1) is not valid for $M_1 \sin\theta \gg 1$ but only for $0 < \beta \sin\theta < 7$, which corresponds to range of values covered in the computer solution of the Taylor-Maccoll cone equations. An additional limitation is introduced by dissociation and/or ionization. For a rough rule of thumb, the effects of these processes on γ behind a shock can be ignored if the freestream Mach is less than 7. Hence, the equations developed in Ref. 1 are limited to the supersonic and low end of the hypersonic range, $0 < \beta \sin\theta < 7$ and $M_1 < 7$.

Reference

[1] Blick, E. F., Walters, R. R., and Von Rosenberg, C., "Similarity Rule Estimation Methods for Cone Flow with Variable Gamma," *AIAA Journal*, Vol. 6, No. 5, May 1968, pp. 959–961.

Received November 2, 1970.

* Professor, School of Aerospace, Mechanical and Nuclear Engineering. Member AIAA.