Technical Comments

Comparison of NASA Helium Tunnel Transition Data with Noise-Transition Correlation

S. R. PATE*
ARO, Inc., Arnold Air Force Station, Tenn.

RECENT boundary-layer transition Reynolds number $(Re_t)_\delta$ data obtained on a sharp slender cone in the NASA Langley 22-in.-diam helium tunnel at $M_\infty = 21$ have been reported by Fischer and Wagner.[1] The purpose of this Comment is to compare these new data with the aerodynamic noise-transition correlation reported in Ref. 2. The noise-transition correlation was initially developed for sharp flat plates by Pate and Schueler[3] and later extended to sharp slender cones by Pate.[2]

In Ref. 1 (e.g., Fig. 8) Fischer and Wagner compared the helium tunnel data to an earlier correlation published by Pate[4] and found that the correlation prediction was about 60% higher than the helium tunnel data.

The difference between the correlating parameters used in Refs. 2 and 4 is the tunnel size normalizing parameter. In

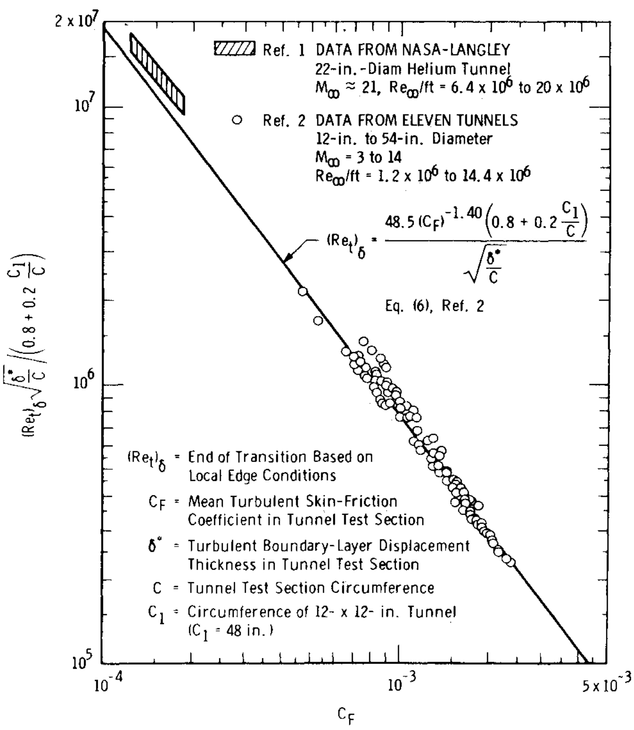

Fig. 1 Comparison of NASA helium tunnel sharp cone transition data with noise-transition correlation.[2]

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* Manager, Aerodynamics Projects Branch, von Kármán Gas Dynamics Facility. Associate Fellow AIAA.

Ref. 4, the parameter $[0.56+0.44\,(C1/C)]$ (which was developed for sharp flat plates[3]) was used; whereas, in Ref. 2, it was found that the parameter $[0.8+0.2\,(C1/C)]$ provided a better correlation of the sharp cone data.

Presented in Fig. 1 are the Langley data compared with the noise-transition correlation and empirical equation from Ref. 2, and good agreement is seen to exist. It is to be noted the Langley data lie about an order of magnitude outside the range of data used in Ref. 2. The total skin friction coefficient (C_F) and the parameter $(Re_t)_\delta(\delta^*/C)^{1/2}$ used in Fig. 1 for the Langley data are the values reported in Ref. 1. The results presented in Fig. 1 show that the revised noise-transition correlation and empirical equation of Pate[2] provides a satisfactory prediction of the transition Reynolds numbers obtained in the Langley helium tunnel.

References

[1] Fischer, M. C. and Wagner, R. D., "Transition and Hot-Wire Measurements in Hypersonic Helium Flow," *AIAA Journal*, Vol. 10, No. 10, Oct. 1972, pp. 1326–1332.

[2] Pate, S. R., "Measurements and Correlations of Transition Reynolds Numbers on Sharp Slender Cones at High Speeds," *AIAA Journal*, Vol. 9, No. 6, June 1971, pp. 1082–1090.

[3] Pate, S. R. and Schueler, C. J., "Radiated Aerodynamic Noise Effects on Boundary-Layer Transition in Supersonic and Hypersonic Wind Tunnels," *AIAA Journal*, Vol. 7, No. 3, March 1969, pp. 450–457.

[4] Pate, S. R., "Measurements and Correlations of Transition Reynolds Numbers on Sharp Slender Cones at High Speeds," AEDC-TR-69-172, Dec. 1969, Arnold Engineering Development Center, Arnold Air Force Station, Tenn.

Comment on "Spherically-Symmetric Supersonic Source Flow: A New Use for the Prandtl-Meyer Function"

IVAN E. BECKWITH*
NASA Langley Research Center, Hampton, Va.

IN a recent Note, Reddall[1] derived for the subject flow, relations between Mach number M, area ratio, and radius to the source R. He also derived parametric equations for the characteristic curves in this flow, in terms of M, R, and the flow angle θ, and states that these equations are "not well documented, if at all." These latter equations were apparently derived for the first time in Ref. 2 and have since been used extensively in the design of wind-tunnel nozzles.[3–5]

Reddall[1] also points out the "remarkable result" that the integral of θ between two points along a characteristic is one-half the change in the Prandtl-Meyer function between these

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* Head, Gas Dynamics Section, Hypersonic Vehicles Division. Associate Fellow AIAA.

points. He concludes[1]: "The appearance of the Prandtl-Meyer function in the solution of a three-dimensional flow is believed to be a new result." Again this relation was apparently first derived in Ref. 2 and also by Beckwith[3] [Eq. (A9), Ref. 3] who termed the integral of θ the "total expansion angle" by analogy with the Prandtl-Meyer turning angle in two-dimensional flow. Sivells[5] noted this expansion angle in spherical radial flow is one-half the Prandtl-Meyer expansion angle in two-dimensional flow.

Reddall's[1] generalization to real gases was first developed and used by Johnson et al.[4] Thus, all of Reddall's "new results" have been recognized and used by fluid mechanicians for many years. Nevertheless, it is gratifying to see old results derived by a fresh approach and used in new applications.

References

[1] Reddall, W. F., III, "Spherically-Symmetric Supersonic Source Flow: A New Use for the Prandtl-Meyer Function," *AIAA Journal*, Vol. 11, No. 12, Dec. 1973, pp. 1787–1789.

[2] Foelsch, K., "The Analytical Design of an Axially Symmetric Laval Nozzle for a Parallel and Uniform Jet," *Journal Aerospace Sciences*, Vol. 16, No. 3, March 1949, pp. 161–166, 188.

[3] Beckwith, I. E., Ridyard, H. W., and Cromer, N., "The Aerodynamic Design of High Mach Number Nozzles Utilizing Axisymmetric Flow With Application to a Nozzle of Square Test Section," TN 2711, June 1952, NACA.

[4] Johnson, C. B., Boney, L. R., Ellison, J. C., and Erickson, W. D., "Real-Gas Effects on Hypersonic Nozzle Contours With a Method of Calculation," TN D-1622, April 1963, NASA.

[5] Sivells, J. C., "Aerodynamic Design of Axisymmetric Hypersonic Wind-Tunnel Nozzles," *Journal of Spacecraft and Rockets*, Vol. 7, No. 11, Nov. 1970, pp. 1292–1299.

Reply by Author to I. Beckwith

WALTER F. REDDALL III*
The Aerospace Corporation, El Segundo, Calif.

BECKWITH'S informative Comment not only reveals the prior appearance in the literature of the results derived independently in the subject Note, but also underscores the risk involved in surmising publicly that one's analysis is "new" to a field that has been as intensively probed as gasdynamics. The practical application in the earlier work of the exact equations of the characteristic curves for a spherically-symmetric flow to the problem of designing axially-symmetric Laval nozzles is quite interesting. Submergence of the key spherical flow results amid the discussions of approximate techniques used in general nozzle design may have tended to obscure them. It does not seem unreasonable to maintain that the fact that the Prandtl-Meyer function appears in the exact solution of a nonplanar flow is not widely known. It is to be hoped that publication of the subject Note, which presents in unified form the derivation for both perfect and real gases, and this subsequent Comment will at least serve to bring more widespread attention to that fact. As a minor point it may be observed that the expressions for the curvature of a characteristic and position of the inflection point presented in the Note do not seem to appear in the references cited by Beckwith.

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* Member of the Technical Staff.