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

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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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