Technical Comments

Comment on "Study of an Asymmetric Flap Nozzle as a Thrust-Vectoring Device"

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A RECENT article by Wu and Chow[1] prompted me to draw attention to the following points.

1) For convergent nozzles, validation of computation codes by pressure measurements along the walls is not sufficient. In actual fact, in the forward end of the convergent (Mach 0,7) the static pressure is not affected much by small variations of test Mach number. In the aft end, the pressure gradients along the abscissa are too high to allow a fair evaluation of differences.

2) When validating a method of the same type (1972)[2] for convergent conical nozzles (axisymmetrical flow), we have tried to validate our methods by experimental overall (flow and thrust coefficients) and local (sonic line) cross-checks.[3,4]

Apart from these above comments, we agree that this method is suitable for straight wall nozzles. SNECMA has developed a similar method for thrust vectoring nozzles. In addition, the straightforward coupling of the hodograph method with the method of characteristics yields a mixed method of providing for rapid calculation of supersonic convergent-divergent nozzles.[5]

References

[1]Wu, C.C. and Chow, W.L., "Study of an Asymmetric Flap Nozzle as a Thrust-Vectoring Device," *Journal of Propulsion and Power*, Vol. 1, July-Aug. 1985, pp. 286-291.

[2]Fenain, M., and Carriere, P., "Application des methodes de resolution hodographique á l'etude de jets et de profils supercritiques," ONERA TN 5/1285 AN, Nov. 1970.

[3]Fenain, M., Dutouquet, L., and Solignac, J.L., "Flow Calculation of Convergent Propulsive Nozzles Comparison with Experiment," ICAS Paper 74-44, Haifa, Israel, Aug. 1974.

[4]Hardy, J.M. and Dutouquet, L., "Etude de l'ecoulement dans un ejecteur transsonique," ISABE, Sheffield, England, March 1974.

[5]Dutouquet, L. and Hardy, J.M., "Engine Aerodyanmic Installation by Numerical Simulation," AIAA Paper 80-108, 1980.

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Reply by Authors to J. M. Hardy

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WE wish to thank Mr. Hardy for his interest and comment on our article. We were well aware of the similar type of work on the method on hodograph transformation carried out in ONERA and SNECMA in France, but were unaware that this method has been applied to the computation of thrust-vector devices. Once the idea is pointed out, these computations can be carried out by qualified individuals. This writer had the benefit of learning, through this series of computations, that the sonic line may not necessarily terminate at the end of the straight flap, rather it may terminate at any point on the flap if the operating and geometric conditions call for it.

Although Mr. Hardy's comment on the insensitivity of the upstream pressure level to the free jet Mach number may have been based upon his practical experience, it is nevertheless known that the pressure distribution on the boundary is the result of the character of the boundary value problem. A simple way of checking the validity of computations may still be based upon the pressure measurement not only on the horizontal wall but also on the side walls. In fact the pressure readings along the side wall can help to locate the sonic line. Any other valuable measurements can always be made if the necessary instrumentations are available. Unfortunately, only simple pressure measurements coupled with schlieren observations were possible in our laboratory at the period of this investigation. Furthermore, we had no intention to extensively explore the flowfield through experimentation.

We would also like to point out that other than the possible numerical errors, the solution established by the present method is exact to the problem. Although the pressure changes drastically near the end of the physical flap, it is quite a different matter in the hodograph plane. This writer would like to add that nozzles with curved solid walls have also been treated on the basis of hodograph transformation.[2,3]

References

[1]Wu, C.C. and W.L. Chow, "Study of an Asymmetric Flap Nozzle as a Thrust-Vectoring Device," *Journal of Propulsion and Power*, Vol. 1, July-Aug. 1986, pp. 286-291.

[2]Chow, W.L. and P. Chan, "The Effect of Gravity on Curved Channel Potential Flows," *Journal of Fluid Engineering*, Vol. 103, No. 4, 1981, pp. 639-643.

[3]Chan, P. and W.L. Chow, "The Study of Gravitational Nozzle Flows by Hodograph Transformation," *Journal of Applied Mechanics*, Vol. 51, No. 3, 1984, pp. 457-464.

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