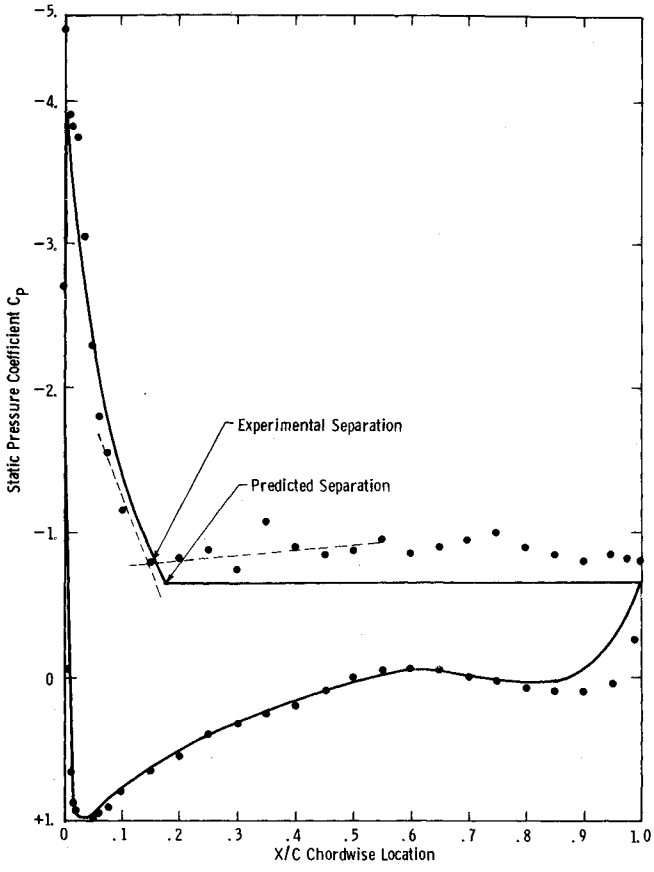

Fig. 1 Comparison of theoretical (automated algorithm) airfoil pressure distribution and of experimental data for NASA GA(W)-1 airfoil at 21.14 deg angle of attack.

with massive turbulent flow separation. The separation criterion employed in the algorithm was that of Goldschmied.[8]

The authors investigated experimentally the NASA GA (W)-1 airfoil up to 18° angle of attack, with turbulent separation up to 45% chord from the leading edge.

Figure 1 (reproduced from Ref. 7) presents the experimental and theoretical pressure distribution on the very same NASA GA(W)-1 airfoil at the extreme 21° angle of attack, where flow separation starts at 15% chord from the leading edge. As it can be readily seen, the agreement between theory and experiment is quite good, and 85% flow separation can be classified as massive. As a concluding comment, it can be said that our theoretical success at 21° is three times as significant as a similar success at 18°, in inverse proportion of the respective separation distance from the leading edge.

References

[1] Seetharam, H.C. and Wentz, W.H., Jr. "Experimental Investigation of Subsonic Turbulent Separated Boundary-Layers on an Airfoil," *Journal of Aircraft*, Vol. 14, Jan. 1977, pp. 51-55.

[2] Liebeck, R.H., "A Class of Airfoils Designed for High Lift in Incompressible Flow," *Journal of Aircraft*, Vol. 10, Oct. 1973, pp. 610-617.

[3] Stevens, W.A., Goradia, S.H., and Braden, J.A., "Mathematical Model for Two-Dimensional Multi-Component Airfoil in Viscous Flow," NASA CR-1843, July 1971.

[4] Bhateley, I.C. and McWhirter, J.W., "Development of Theoretical Method for Two-Dimensional Multi-Element Airfoil Analysis and Design. Part 1 – Viscous Flow Analysis Method," Air Force Flight Dynamics Lab., Wright Patterson AFB, Ohio, AFFDL-TR-73-96, Aug. 1972.

[5] Hahn, M., Rubbert, P.E., and Mahal, A.S., "Evaluation of Separation Criteria and Their Applications to Separated Flow Analysis," Air Force Flight Dynamics Lab., Wright Patterson AFB, Ohio, AFFDL-TR-72-145, Jan. 1973.

[6] Kuhn, G.D. and Nielsen, J.N., "Prediction of Turbulent Separated Boundary Layer," *AIAA Journal*, Vol. 12, July 1974, pp. 881-882.

[7] Farn, C.L.S., Goldschmied, F.R., and Whirlow, D.K., "Pressure Distribution Prediction for Two-Dimensional Hydrofoils with Massive Turbulent Separation," *Journal of Hydronautics*, Vol. 10, July 1976, pp. 95-101.

[8] Goldschmied, F.R., "An Approach to Turbulent Incompressible Separation Under Adverse Pressure Gradients," *Journal of Aircraft*, Vol. 2, March/April 1965, pp. 108-115.

Reply by Authors to F.R. Goldschmied

H.C. Seetharam* and W.H. Wentz Jr.†
Wichita State University, Wichita, Kan.

UNFORTUNATELY, the results of the Westinghouse research[1] did not appear in the open literature until after the Wichita State University paper had been accepted for publication. The principal limitation of the Westinghouse method seems to be the necessity of using an experimental correlation to obtain the correct level of pressure in the separated flow region.

Another theoretical approach which is capable of determining the separation pressure theoretically and which accounts for the wake flow in some detail is currently being developed by Naik[2] and Zumwalt.

References

[1] Farn, C.L.S., Goldschmied, F.R., and Whirlow, D.K., "Pressure Distribution Prediction for Two-Dimensional Hydrofoils with Massive Turbulent Separation," *Journal of Hydronautics*, Vol. 10, July 1976, pp. 95-101.

[2] Naik, S.N., "An Analytical Model for the Study of Highly Separated Flows on Subsonic Airfoils," Ph.D. dissertation, in review at Wichita State University, 1977 (G.W. Zumwalt, advisor).

Received April 14, 1977.

Index categories: Aircraft Aerodynamics (including Component Aerodynamics); Boundary Layers and Convective Heat Transfer – Turbulent; Jets, Wakes and Viscid-Inviscid Flow Interactions.

*Research Associate, Department of Aeronautical Engineering. Member AIAA.

†Professor, Department of Aeronautical Engineering. Associate Fellow AIAA.