Technical Comments

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Comment on "Water Tunnel Flow Visualization: Insight into Complex Three-Dimensional Flowfields"

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THERE are two comments which need to be made with regard to the subject paper (Ref. 1). The first is that extreme care must be exercised in establishing vortex breakdown from inflections in the lift curve slope for strake-wing configurations. This can be illustrated by the fact that when the vortex lift theory solutions incorporating all of the trigonometric terms (Polhamus' Suction Analogy—Ref. 2) are used, there is a naturally occurring inflection in the lift curve, i.e., a reduction in the lift curve slope, commencing about $\alpha = 16$ deg (Ref. 3) and it is unassociated with vortex breakdown.

The second comment is that regarding the correlation of wind tunnel force data with water tunnel flow photographs, it must be kept in mind that discrepancies do exist between the vortex breakdown angles observed on strake-wing configurations in the wind tunnel and low Reynolds number water tunnel. (See Ref. 4, for example.) So although the water tunnel appears to provide useful qualitative configuration effect information, it may be questioned from a quantitative standpoint.

In view of the preceding comments, one should use extreme caution in applying the vortex breakdown analysis method outlined in the subject paper to strake-wing configurations.

References

[1] Erickson, G.E., "Water Tunnel Flow Visualization: Insight into Complex Three-Dimensional Flowfields," *Journal of Aircraft*, Vol. 17, Sept. 1980, pp. 656-662.

[2] Polhamus, E.C., "A Concept of the Vortex Lift of Sharp-Edge Delta Wings Based on a Leading-Edge Suction Analogy," NASA TN D-3767, 1966.

[3] Lamar, J.E., "Analysis and Design of Strake-Wing Configurations," *Journal of Aircraft*, Vol. 17, Jan. 1980, p. 20-27.

[4] Lamar, J.E. and Frink, N.T., "Experimental and Analytical Study of the Longitudinal Aerodynamic Characteristics of Analytically and Empirically Designed Strake-Wing Configurations at Subcritical Speeds," NASA TP1803, 1981.

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Reply by Author to J. E. Lamar

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EXPERIMENTAL lift characteristics of several strake-wing configurations (see Refs. 1-3, for example) reveal a significant variation in the angle of attack at which a lift curve slope inflection point occurs. A similar, large variation in the angle of attack for initial bursting of the strake vortex over the wing surface is observed in a low-Reynolds-number water tunnel facility. The paper in question "Water Tunnel Flow Visualization: Insight into Complex Three-Dimensional Flowfields" presents water-to-air correlations of thin, flat-plate, sharp-leading-edge strake-wing geometries at angles of attack where the flowfield is vortex-dominated (that is, the scale of the strake leading-edge vortex is much greater than the wing boundary layer thickness). Under these conditions, vortex flow behavior is expected to be governed by potential flow effects. Consequently, quantitative comparisons of water tunnel vortex breakdown characteristics with wind tunnel force data are possible. The discrepancies between water tunnel and wind tunnel vortex burst locations cited by Lamar may be more indicative of different model support interference effects (which are most pronounced when vortex breakdown occurs aft of the wing trailing edge) and methods of flow visualization than a Reynolds number effect. Model support interference effects on vortex stability characteristics are documented in Ref. 4.

The author agrees with Lamar's comment regarding the judicious application of water tunnel results to higher Reynolds number data obtained in air. Quantitative configuration effect information is not possible in a water tunnel at low angles of attack where vortex flow-boundary layer interaction is significant or where flow separation is not fixed at a salient edge (as would occur, for example, on a strake-wing configuration with round leading edge or deflected leading-edge flap). The strength of a water tunnel facility lies in the qualitative information which can be gained from complex vortex flowfields. It should not be discounted, however, that under certain restrictive conditions useful quantitative information can be derived from water tunnel studies. A detailed discussion of the proper utilization of a hydrodynamic test facility in the study of separation-induced vortex flows and water flow interactions is provided in Ref. 5.

References

[1] Erickson, G. E., "Flow Studies of Slender Wing Vortices," AIAA Paper 80-1423 presented at the 13th Fluid and Plasma Dynamics Conference, Snowmass, Colo., July 14-16, 1980.

[2] Lamar, J.E., "Strake-Wing Analysis and Design," AIAA Paper 78-1201 presented at the 11th Fluid and Plasma Dynamics Conference, Seattle, Wash., July 10-12, 1978.

[3] Luckring, J.M., "Theoretical and Experimental Aerodynamics of Strake-Wing Interactions up to High Angles of Attack," AIAA Paper 78-1202 presented at the 11th Fluid and Plasma Dynamics Conference, Seattle, Wash., July 10-12, 1978.

[4] Johnson, J.L., Grafton, S.B., and Yip, L.P., "Exploratory Investigation of the Effects of Vortex Bursting on the High-Angle-of-Attack Lateral-Directional Stability Characteristics of Highly-Swept Wings," AIAA Paper 80-0463 presented at the 11th Aerodynamic Testing Conference, Colorado Springs, Colo., March 18-20, 1980.

[5] Erickson, G.E., "Vortex Flow Correlation," AFWAL-TR-80-3143, Jan. 1981.

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