Model Support Effects on Aerodynamic and Wake Characteristics of Large Angle Cones

MELVIN M. CARMEL* AND CLARENCE A. BROWN JR.†
NASA Langley Research Center, Hampton, Va.

Theme

DATA from wind-tunnel experiment are presented showing the effects of sting diameter and small Reynolds number variation in the low range on the aerodynamic characteristics of a 140° cone at $M = 1.50$. The effects of support interference on the wake of a 120° cone at $M = 1.60$ are also presented.

Content

The Langley Research Center of NASA has conducted an experimental program on a 140° cone model in an attempt to gain more insight into such factors as Reynolds number effects and sting-support interference in wind-tunnel tests of decelerator-shaped vehicles.

In addition, an effort was made to assess the cause of experimentally observed asymmetric wake patterns behind blunt bodies, often attributed to model and/or support asymetrics, by utilizing an existing tunnel-spanning support and a single wall-mounted support in tests with the same model.

The tests were performed in the Langley Unitary Plan wind tunnel. The 140° cone force tests were performed at $M = 1.50$ and 2.00 through an angle-of-attack range from about $-3°$ to 13° at Reynolds numbers from 1.74×10^5 to 1.44×15^5 based on model diameter, D. Sting support diameters varied from 0.125 d/D to 0.500 d/D. The wake survey tests behind a 120° cone were performed at a Mach number of 1.60, at angles-of-attack of 0° and 5°, and at a Reynolds number of 6.60×10^5. Additional force data on the 140° cone at $M = 1.50$ and 2.0 and wake survey data on the 120° cone at different x/D distance may be found in Ref. 1.

The results of the force tests are presented in coefficient form about the body axis with the moment reference located at the model base. These coefficients are nondimensionalized with base area and base diameter of the cone. Base pressure tubes were located at the centroid of area on the base of the cone at 90° intervals and also in the balance cavity. Chamber and base pressures were measured on all sting-diameter configurations; however, the axial-force coefficients are for total values and have not been corrected for base pressure. In the wake survey measurements, two support systems were used with the 120° cone. One support system was mounted in such a manner as to span the tunnel test section. The second support system was a single-strut, mounted on the wall of the tunnel. The wake survey results are presented as the ratio of local dynamic pressure to that in freestream. Local pressures were measured by means of a multitube rake. The rake was mounted in a vertical position in the tunnel and could be moved laterally and longitudinally in the test section.

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* Aerospace Engineer. Member AIAA.

† Aerospace Engineer.

The results of tests on the 140° cone in which Reynolds number was varied (Fig. 1) indicate that there is little or no effect of Reynolds number on the normal-force, axial-force, or pitching-moment characteristics of the model. Comparisons of these data with those reported by Campbell show little or no effect of Reynolds number on these characteristics up to 8×10^5.

For sting diameter ratios up to 0.500, the data shown in Fig. 2 indicate no significant effect on normal-force or pitching-moment characteristics of the model. In addition, there is no appreciable effect on the axial force for increases in d/D values up to at least 0.312. For sting diameter ratios of 0.417 and 0.500, however, there is a noticeable increase in axial force coefficient at low angles of attack.

The data of Fig. 3 indicate a slight decrease in base-pressure coefficient with increase in Reynolds number; however, the axial force that may be determined from the integrated average of the pressures at the different Reynolds numbers is evidently within the accuracy of the axial-force measurements since little or no change in C_A was noted due to RN variation. The data, however, show higher base pressures on the leeward side of the cone at small angles of attack which would explain the increase in stability level usually noted for high angle cones in this angle-of-attack range. Thus it may be surmised that

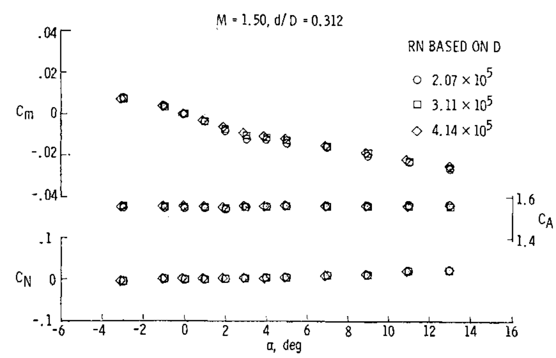

Fig. 1 Effect of Reynolds number on aerodynamic characteristics.

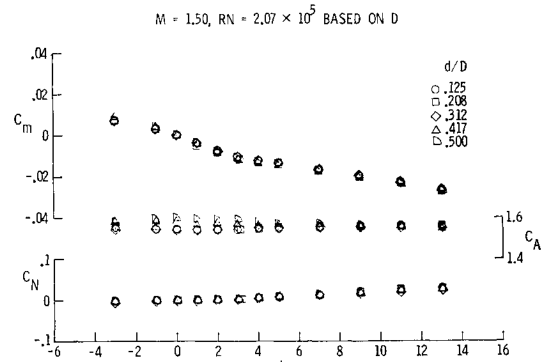

Fig. 2 Effect of sting diameter on aerodynamic characteristics.

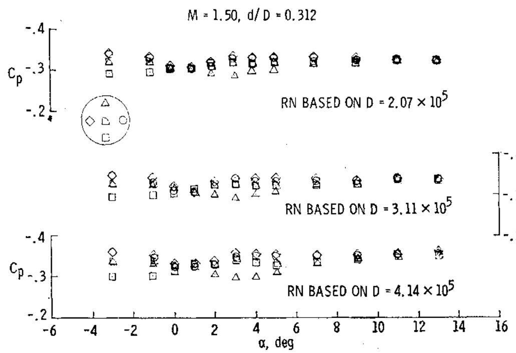

Fig. 3 Effect of Reynolds number on base pressure coefficients.

detailed pressure surveys of the base of cones may be required if loads on the base become a critical factor.

There is a decrease in pressure coefficients on the base with increase in sting diameter ratio at low angles of attack although the predominant effects are noted for the two larger sting diameters (Fig. 4). These pressure data explain the increase in C_A noted for sting diameter effects from the force data.

The results of wake survey tests for a 120° cone on the

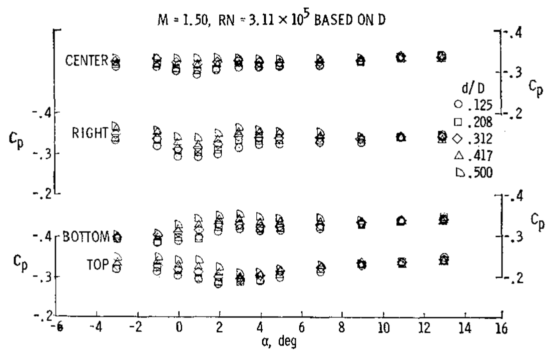

Fig. 4 Effect of sting diameter on base pressure coefficients.

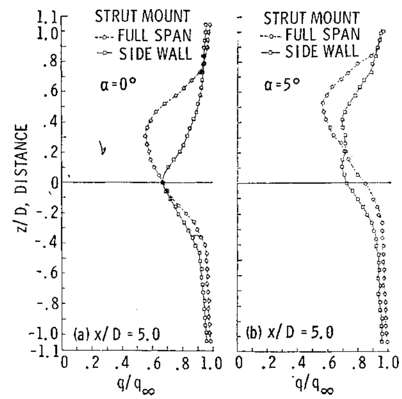

Fig. 5 Effect of support arrangements on q/q_∞ profiles, $M = 1.60$.

tunnel-spanning support system are shown in Fig. 5. These results show asymmetric flow patterns which would not be expected for the cone at $\alpha = 0°$ especially since Campbell and Grow have shown a symmetrical wake pattern for the same cone on a different support at $M = 2.20$. Tests with the single wall-mount strut show an extremely smooth pressure pattern for the cone at $\alpha = 0°$. Subsequent inspection of the tunnel-spanning strut showed that when the model was tightened in position considerable strut warpage was incurred. Comparisons of the data with both supports show that the strut warpage not only induces an asymmetric wake pattern but also leads to greater pressure losses. From these results, it may be concluded that extreme care must be exercised to assure that both the strut support and the test body be accurately aligned in order to avoid significant error in the wake profile distribution as well as in the wake pressure levels.

Reference

[1] Carmel, M. M. and Brown, C. A., Jr., "Supersonic Aerodynamic and Wake Characteristics of Large-Angle Cones at Low Reynolds Numbers Including Effects of Model Support," AIAA Paper 71-264, Albuquerque, N. Mex., 1971.