for a rotating cylinder evaluated by Eq. (5) are depicted as functions of rotation rate. When $Re_\infty > Re_{c2}$, normal force (or drag) coefficient C_N increases monotonically as the Reynolds number increases. (Figure 3 shows the case for $V_\infty = 30$ m/s.) This will explain why the drag force on a rotating body in the drop test is greater than that on the model at rest in the wind tunnel test.[2]

In view of the rough approximate analysis, qualitative agreement with the experimental data is encouraging as a method to predict the maximum rotation rates near critical Reynolds number.

From the practical point of view, the flat spin will be prevented by making the boundary layer on the whole surface of the body turbulent with artificial roughness elements such as tripping wires.[10]

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Subsonic and Transonic Roll Damping Measurements on Basic Finner

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Nomenclature

C_l = rolling moment/$q_\infty Sd$, rolling moment coefficient
C_{l_p} = $\partial C_l / \partial (pd/2V_\infty)$, roll damping coefficient
d = body diameter
M_∞ = freestream Mach number
p = roll rate, rad/s
q_∞ = freestream dynamic pressure
Re_d = Reynolds number based on body diameter
S = $\pi d^2/4$, reference area
V_∞ = freestream velocity

Introduction

DEVELOPMENT of new test techniques and prediction methods for aerodynamic coefficient estimation to meet the increasing needs of industry is a well-known feature of aerospace research and development. It is general practice to validate these new methods by generating data and comparing them with other available results on a widely accepted configuration—the so-called calibration model. It is reported[1] that the Basic Finner (Fig. 1) has been selected as a standard configuration for this purpose by the Supersonic Tunnel Association and AGARD. Consequent to this, experimental results of aerodynamic coefficients on this configuration is obviously of general interest. To fulfill this need, Ref. 1 presented wind-tunnel measured pitch damping and stiffness coefficients on the Basic Finner at $M_\infty = 1.5$.

Measurements of roll damping coefficient on the Basic Finner are reported in Refs. 2-4. These measurements covered the supersonic speed range. Excepting $M_\infty = 0.22$ and 0.77, there does not seem to be any published test data on this configuration at subsonic and transonic speeds. This Note presents wind-tunnel roll damping data on the Basic Finner in

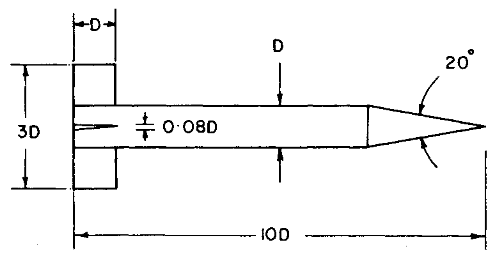

Fig. 1 Basic Finner model.

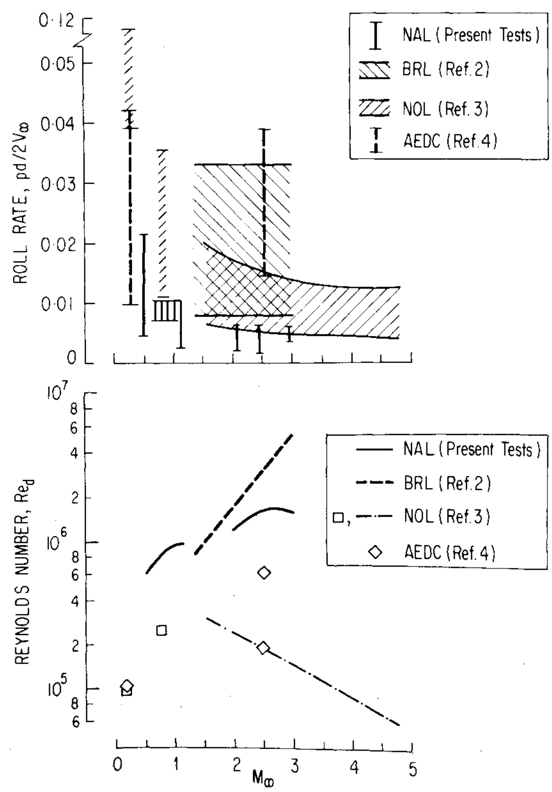

Fig. 2 Roll rate and Reynolds number of tests.

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Table 1 Details of tests

Source	Test technique	Model diam, mm	Boundary layer trip	Measurement accuracy of C_{l_p}
NAL (present tests)	Steady roll	36.0	Yes[a]	5% transonic 3% supersonic
BRL (Ref. 2)	Free flight	20.0	–[b]	–[b]
NOL (Ref. 3)	Free decay	19.05	–[b]	5%
AEDC (Ref. 4)	Free decay	45.7	–[b]	4% subsonic 3% supersonic

[a] Some tests at $M_\infty = 0.5$ and 0.77 were also without trips.
[b] Data not available.

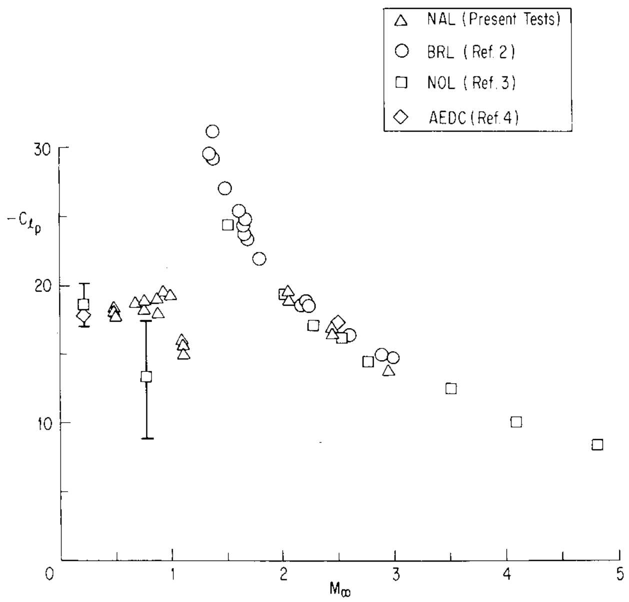

Fig. 3 Roll damping coefficient.

the latter speed range to fill this important gap. Additional measurements at a few supersonic speeds are also included to supplement the currently available data.[2-4]

Measurements

The present measurements were obtained using the steady-roll technique in the National Aeronautical Laboratory 0.3 m trisonic wind tunnel. Rolling moment on the model at different steady-roll rates was measured by an internal strain gage balance and the roll damping coefficient C_{l_p} was obtained as the slope of a plot of C_l vs $pd/2V_\infty$. More details of the tunnel and tests are found in Ref. 5. Test parameters are noted in Table 1 and Fig. 2.

Discussion

The present measurements along with the results from tests of Refs. 2-4 at zero incidence are presented in Fig. 3. There is excellent agreement of the present results with other tests[2-4] in the supersonic region, while the agreement with Refs. 3 and 4 at subsonic speeds is satisfactory. The sudden drop in roll damping observed in the transonic region is believed to be due to the occurrence of a shock wave on the fin which causes a drop in fin lift; this drop is reflected in C_{l_p} since roll damping is caused essentially by the lift produced on the fins due to the antisymmetric incidence distribution induced by the roll rate. It is interesting to note that predictions,[6] which assumed that the roll damping varied in accordance with normal force coefficient, had indicated the occurrence of a dip in C_{l_p} at nearly the same Mach number as in the present tests; flight test results[7] (not shown here) on a similar rectangular wing-body combination (aspect ratio = 3.7) also showed a dip in C_{l_p} in the transonic region.

Another noteworthy point is that the measured C_{l_p} was invariant with roll rate, $pd/2V_\infty$ at all Mach numbers in the present tests and in the measurements of Refs. 2 and 4 at zero incidence. However, in the tests of Ref. 3 this was true only at supersonic speeds, while C_{l_p} was found to increase with roll rate at $M_\infty = 0.22$ and 0.77 (the results at these Mach numbers are, therefore, shown in Fig. 3 by bars indicating the range of values obtained). This result, for which no explanation was offered, could be responsible for the differences shown between the present tests and those of Ref. 3 at $M_\infty = 0.77$.

Conclusion

Wind-tunnel roll damping measurements on the Basic Finner model at subsonic and transonic speeds are presented. These measurements cover the gap in the currently available experimental data on this standard model and along with those of Refs. 2-4 provide a reference data base for assessment of new testing and analytical techniques.

Acknowledgments

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