# Experimental Investigation of Support Interference on an Ogive Cylinder at High Incidence

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## Abstract

A WIND-TUNNEL test was conducted to determine the support interference on an ogive-cylinder model at high angles of attack in transonic flow. The model was supported by either a base-mounted sting or a strut attached to the leeside of the model. The strut support acted as a splitter plate and generally reduced the normal-force coefficient, while the sting support increased the normal-force coefficient slightly. The support interference diminished with increasing Mach number. A simple algebraic method of estimating support interference was used. Two semiempirical methods for calculation of aerodynamic coefficients were compared with test results.

## Contents

Recent missile developments require missiles to perform over a wide range of incidence and Mach number.[1,2] Wind-tunnel data for the aerodynamic coefficients of bodies of revolution at high incidence are therefore needed for design and development of prediction methods.[3,4] The model may be supported by either a base-mounted sting or a strut attached to the leeside of the model. In Ref. 4, data obtained at high incidence for these two support systems were found to differ by up to 30% in the incidence range from 65-100 deg. Therefore, a program was conducted to evaluate the support interference for a missile body at high incidence over a range of Mach number and Reynolds number where the aerodynamic coefficients exhibit the most disparity, as reported in Ref. 4.

The experimental portion of this study was conducted in the AEDC Aerodynamic Wind Tunnel (4T) (test section dimensions $1.22 \times 1.22$ m). The ogive-cylinder model (length = 31.75 cm, diam = 3.18 cm) was supported by either a sting or a strut. The capability of mounting a dummy sting or strut was also incorporated. The support configurations are shown in Fig. 1. Each configuration (sting only, strut only, sting with dummy strut, and strut with dummy sting) was tested at Mach numbers of 0.6, 0.8, and 0.9, and model Reynolds numbers ($R$, based on model length) of 2, 3, and $4 \times 10^6$. Angle of attack ranged from 64-100 deg. Force measurements were acquired through a 6-component balance mounted in the model.

A comparison of $C_N$ vs angle of attack for the sting- and strut-supported models is shown in Fig. 2 for $R = 2 \times 10^6$ and $M_\infty = 0.6$, 0.8, and 0.9. The sting-supported model exhibits a general increase in $C_N$ as angle of attack approaches 90 deg. In addition, $C_N$ generally increases as Mach number increases. The Mach number effects become less pronounced near 90 deg. However, the strut-mounted model exhibits a steady increase in $C_N$ as Mach number increases, with no lessening of Mach number effects as angle of attack approaches 90 deg. The greatest discrepancy in $C_N$ between the two support configurations occurs at $M_\infty = 0.6$. As Mach number increases, the discrepancy diminishes. The data for $C_N$ vs angle of attack for $R = 4 \times 10^6$ and $M = 0.8$ show significant Reynolds number effects for the sting-mounted model, while the strut-mounted model exhibits virtually no Reynolds number effects.

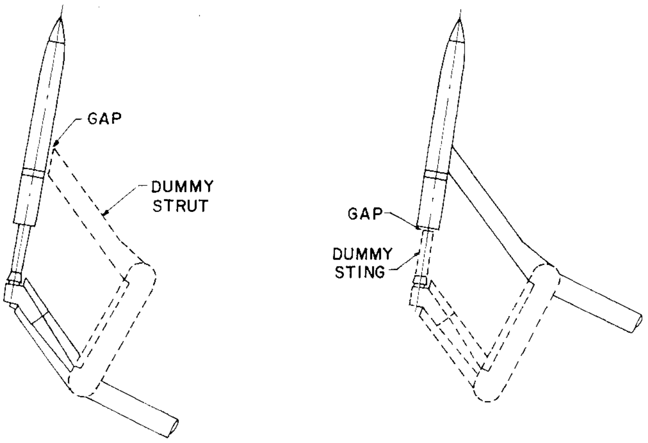

Fig. 1 Model support configurations.

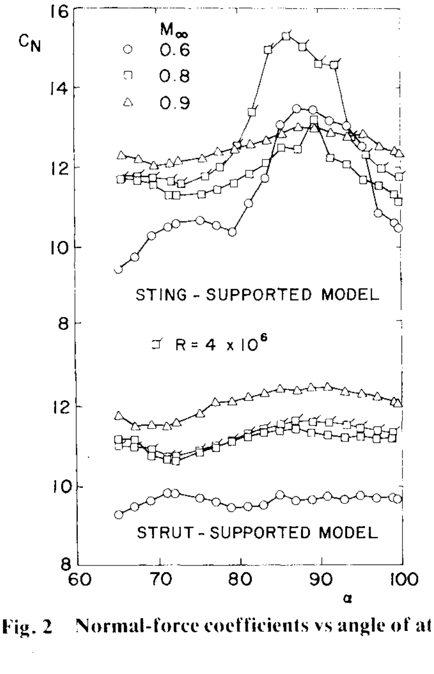

Fig. 2 Normal-force coefficients vs angle of attack.

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The support interference and interference results may be estimated by means of simple algebraic computations. The interference levels of the sting and strut are first calculated as follows:

$$\Delta C_{N_{\text{sting}}} = C_{N_{\text{sting plus strut}}} - C_{N_{\text{strut}}}$$

$$\Delta C_{N_{\text{strut}}} = C_{N_{\text{strut plus sting}}} - C_{N_{\text{sting}}}$$

where

$$C_{N_{\text{strut}}}, C_{N_{\text{sting}}}, C_{N_{\text{sting plus strut}}}, \text{ and } C_{N_{\text{strut plus sting}}}$$

are values obtained for the strut-mounted model, the sting-mounted model, the sting-mounted model with dummy strut, and the strut-mounted model with dummy sting, respectively. $\Delta C_{N_{\text{sting}}}$ and $\Delta C_{N_{\text{strut}}}$ are the changes in normal force attributable to the sting and strut, respectively. The $\Delta C_N$ values may then be subtracted from the strut support and sting support data to obtain estimates of interference-free $C_N$ values:

$$C_{N_{\text{body}}} = C_{N_{\text{strut}}} - \Delta C_{N_{\text{strut}}}$$

$$C_{N_{\text{body}}} = C_{N_{\text{sting}}} - C_{N_{\text{sting}}}$$

where $C_{N_{\text{body}}}$ is the interference-free value of $C_N$. This method assumes that the effects of the sting and strut supports are additive.

The results from two semiempirical analytical programs were compared to the experimental results. The first calculation, that of Jorgensen,[1] combines potential and viscous flow components to determine the normal-force coefficient on an axisymmetric body. The second calculation utilizes a computer program (CAMS – Computer Aided Missile Synthesis)[5] used in missile design. Both methods require the input of empirical data in the form of cross-flow drag coefficients.

Corrected $C_N$ values are compared with the analytical results in Fig. 3 for $M_\infty = 0.6$ and $R = 3 \times 10^6$. The upper corrected $C_N$ curve is obtained by subtracting sting effects; the lower curve is obtained by subtracting strut effects. The corrected curves do not coincide due to geometric dissimilarities between the sting-mounted model with the dummy strut and the strut-mounted model with the dummy sting. The analytical results compare favorably with the corrected experimental results. Both the corrected data and the analytical results compare more favorably with the sting support data than with the strut support data.

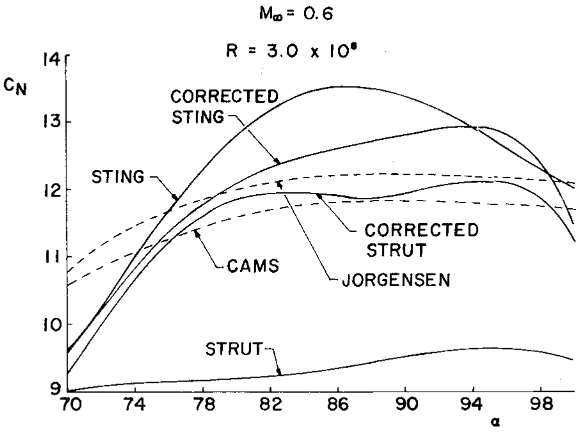

**Fig. 3** **Corrected normal-force coefficient data.**

The strut support appears to have more influence on the measured aerodynamic coefficients than does the sting. The strut support appears to act as a wake splitter plate, resulting in a smoothing of the wake flow and a lower $C_N$ on the model.[6] The sting acts to increase the effective length of the model, resulting in a slightly higher $C_N$. As Mach number increases, the effects of support interference diminish. In the Mach number range studied, a sting support would be preferable to a strut support for a model tested at high incidence.

## References

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