BASE PRESSURE ON AEROFOIL SECTIONS WITH A BLUNT TRAILING EDGE IN SUPERSONIC FLOW

1. NOTATION AND UNITS

		SI	*British*
c	aerofoil chord	m	ft
C_{pb}	base pressure coefficient = $(p_b - p_0)\ /\frac{1}{2}\gamma p_0 M_0^2$		
C_{p1}	C_{pb} at $h/\theta = 100$ (turbulent boundary layer), a function of M_0		
C_{p2}	$C_{pb} - C_{p1}$, a function of h/θ		
h	thickness of blunt trailing edge	m	ft
M_0	free-stream Mach number		
p_b	base pressure	N/m^2	lbf/ft^2
p_0	free-stream static pressure	N/m^2	lbf/ft^2
γ	ratio of specific heat capacities of air		
θ	boundary-layer momentum thickness at base on one side	m	ft

2. NOTES

The base pressure on an aerofoil section with a blunt trailing edge depends on the condition of the boundary layer at the base. The two cases of the turbulent and laminar boundary layers are treated separately in this Data Item. The results on which the Item is based were for sharply truncated bases, and slight rounding at the trailing edge may have an appreciable effect.

The base pressure on an aerofoil section is determined partly by the local conditions outside the boundary layer at the base, but chiefly by the manner in which the pressure in the wake recovers to ambient conditions far downstream. For this reason the base pressure coefficient is expressed in terms of free-stream conditions.

2.1 Turbulent Boundary Layer

A correlation, suggested by Nash[7], of a large collection of experimental data for base pressure in turbulent flow has shown that C_{pb} may be expressed as

$$C_{pb} = C_{p1} + C_{p2},$$

where C_{p1} is a function of M_0 only and is shown in Figure 1a, and C_{p2} is a function of h/θ only and appears on Figure 1b.

The experimental data indicate that these curves give values of C_{pb} to within ± 0.02.

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In using this Item the value of θ at the base is required. As the base pressure is not strongly dependent on h/θ, and having regard for the stated accuracy, a rough estimate of θ is adequate for this purpose and flat plate data are quite suitable.

Derivations 1, 2, 3, 5 and 6 show that, within the accuracy of this Item, the effect on C_{pb} of incidence up to approximately 5° is negligible in the range $1.0 < M_0 < 4.0$.

2.2 Laminar Boundary Layer

Experimental evidence[4] indicates that, when the boundary layer at the base is laminar, the most important parameter affecting the base pressure is the position of the transition point in the wake. As the transition point moves upstream, the base pressure falls from a maximum value (transition downstream of the point of confluence of the separated layers) to a minimum value corresponding to transition in the separated layers. The extreme values of C_{pb} are shown in Figure 2 as a function of Mach number, the line of minimum values corresponding approximately to the base pressure coefficient with turbulent boundary-layer flow at the base, at high values of h/θ.

The variation of the transition position (and hence C_{pb}) is dependent on such factors as the free-stream turbulence level. It is not possible to account precisely for such effects and the variation of C_{pb}, when transition occurs downstream from the base, is therefore not accurately predictable.

3. DERIVATION

The Derivation lists selected sources of information that have assisted in the preparation of this Item.

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4. POTTER, J.L. WHITFIELD, J.D. STRIKE, W.T. — Transition measurements and the correlation of transition sensitive data. Arnold Engineering Development Center, AEDC-TR-59-4, 1959.

5. NASH, J.F. QUINCEY, V.G. CALLINAN, J. — Experiments on two-dimensional base flow at subsonic and transonic speeds. NPL Aero Report 1070, 1963.

6. STAYLOR, W.F. GOLDBERG, T.J. — Afterbody pressures on two-dimensional boattailed bodies having turbulent boundary layers at Mach 5.98. NASA TN D-2350, 1964.

7. NASH, J.F. — A discussion of two-dimensional turbulent base flow. NPL Aero Report 1162, 1965.

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