symmetrically over the surface becomes highly nonuniform at increasing body and angle of attack, generating a region of lower temperature on the leeward side and a region of higher temperature on the windward side. In practical applications a lower average temperature and then a higher average heat transfer rate are inevitable for the entire surface to maintain every point below the maximum permissible temperature for the material used.

To minimize the severe deterioration of the cooling capability of slot injection due to three-dimensional effects, new designs are required for the slot system which give a nonuniform peripheral distribution of the coolant. At this purpose a very simple slot system scheme which counters the cross-flow effects has been investigated in the present study. The scheme consists of nonsymmetric slots, higher on the windward side and lower on the leeward side which, maintaining the average height $S_{eq} = (S_L + S_w)/2$, i.e., the injection coolant mass flow, and producing a nonuniform injection pattern, act to prevent and reduce the negative cross-flow effects on cooling.

The experimental results (Fig. 5), compared with the previous symmetric slot results, generate a more uniform adiabatic wall temperature distribution and thus improve the cooling capability of the system. The results obtained with this primitive nonsymmetric slot scheme are only indicative, however they can suggest a possible direction of investigation.

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Analysis of Predicted Aircraft Wake Vortex Transport and Comparison with Experiment

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Introduction

An aircraft wake vortex transport model has been developed[1] which combines fluid mechanic representations of the various vortex-induced and atmospheric effects. A series of flight tests was conducted to verify the model using B-747, B-707, CV-880, and DC-6 aircraft (over 400 flybys) in which both the motion of the vortices and the attendant meteorological conditions were recorded. The tests were performed at the National Aviation Facilities Experimental Center (NAFEC) in Atlantic City, New Jersey.

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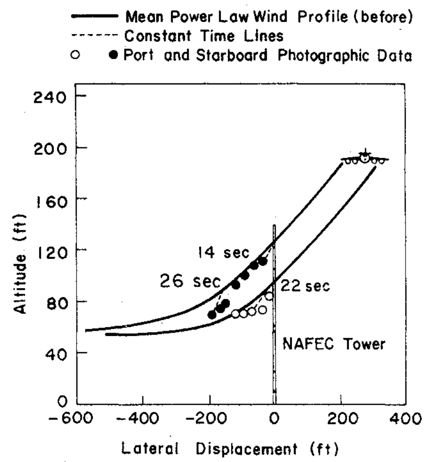

Fig. 1 Comparison of predicted vortex tracks with photographic data for a B-707 flyby (labeled times calibrate the constant time lines and align prediction and observation).

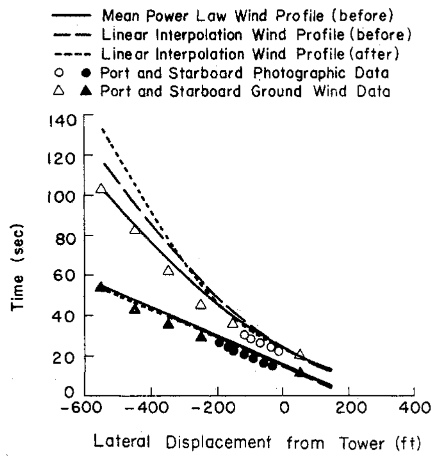

Fig. 2 Comparison of predicted vortex track with measured ground wind data for a B-707 flyby.

Vortex tracks were recorded photographically and by ground-wind sensors. NAFEC has a 140-ft tower instrumented with hot-film anemometers, colored smoke dispensers at 20-ft intervals, and meteorological instrumentation at five levels. The smoke was used to visualize the vortices. A 35-mm camera was positioned 2000 ft from the tower on a line nearly normal to the prevailing wind direction. Photographs were taken every second and the vortex tracks were obtained by examining each photo and locating the vortices by scaling photographic distances with known distances. Gill single-axis propeller anemometers were arrayed on a baseline near the 140-ft tower to measure the wind component perpendicular to the aircraft flight path. As a vortex moved through the anemometer system, it produced a distinctive signature superimposed upon the background wind. The digitized wind sensor data were processed to locate the most probable vortex location as a function of time.[2]

Analysis

Figure 1 shows a typical cross-sectional vortex track compared with a predictive track where the ambient wind was determined by a least-square polynomial fit to the mean wind field averaged for 2 min before the aircraft passage. Figure 2 shows the ground-wind track for the same flyby as in Fig. 1; three predictive tracks are shown: two linear interpolations of the five tower-measured average wind speeds ("before" denotes the mean for the two minutes prior to the aircraft flyby and "after" denotes the two minutes after the flyby),

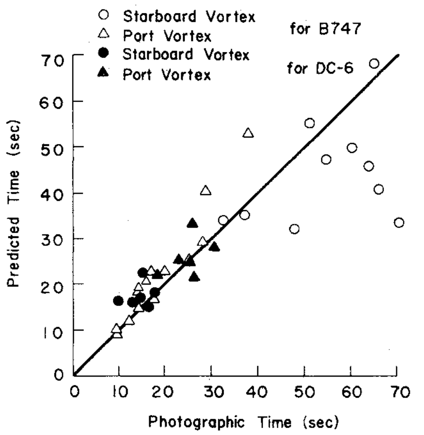

Fig. 3 Comparison of predicted tower hit times vs photographic time for DC-6 and B-747 aircraft flybys.

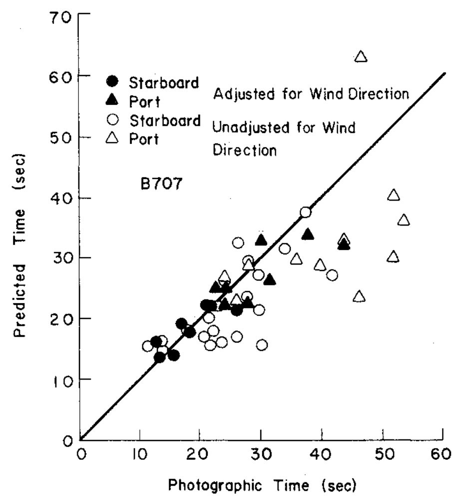

Fig. 4 Comparison of predicted vortex tower-hit times based on power law wind profile vs photographic times.

and a power law profile fit as used in Fig. 1. A power law fit to the mean wind consistently produced better agreement with the vortex tracks partly because of a more accurate wind shear representation at the low altitudes. After about 90 sec the upwind predictive track often lagged behind the data and this is attributed to the rising of the upwind vortex[3] or to a decrease in the circulation of the vortex. The differences between predicted and measured vortex tracks consistently fell within the computed uncertainty in the transport due to random fluctuations in the wind field.

The comparison between predicted and photographically measured times for the vortices to hit the 140-ft tower is shown in Figs. 3 and 4. The wind direction adjustment refers to extrapolation of wind data above the tower to the aircraft cruising altitude (nominally 200 ft).[3] The predicted time is often less than the observed time, especially for older vortices; predicted sink rates based upon elliptical loading assumptions are less than measured rates. There are at least two mechanisms causing the discrepancy, deviations from a clean wing configuration[4] and buoyancy effects[5] leading to decreases in the rolled-up initial vortex separations. Because of the logarithmic variation of the wind magnitude with height, a predicted sink rate which is less than the measured rate will lead to a vortex transport rate in ground effect which is greater than the predicted rate. Uncertainties of up to 25% in the initial vortex separation and 12% in the circulation are contained within the uncertainty in the predicted transport of vortices near the ground due to random fluctuations for winds above 6 fps.

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Maslen Analysis of Exponential Shocks in a Hypersonic Stream

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Nomenclature

a	= bluntness parameter [Eq. (11)]
A	= parameter dependent on a [Eq. (11)]
$F(Z)$	= dimensionless body height
h	= enthalpy, divided by $U_\infty^2/2$
M	= Mach number
p	= pressure, divided by $\rho_\infty U_\infty^2$
P	= pressure, as in Ref. 1
R_C	= shock radius of curvature, Fig. 1
r	= lateral dimension, Fig. 1
$S(Z)$	= dimensionless shock height
U	= freestream velocity
u, v	= velocities in the x,y directions, divided by U_∞, Fig. 1
x,y	= shock-oriented coordinates, Fig. 1
Z	= streamwise coordinate, nondimensionalized by a characteristic length, Fig. 1
ρ	= density, divided by ρ_∞
γ	= ratio of specific heats
δ	= thickness ratio
ψ	= nondimensional stream function
θ	= shock wave inclination to oncoming stream

Subscripts

∞	= freestream value
s	= behind the shock
o	= normal shock
b	= body surface

Introduction

CONCAVE shapes are generally encountered on the lower surfaces of two-dimensional wings in hypersonic flight or in the two-dimensional intake of a hypersonic air-breathing engine. Analytical results on the problem of inviscid flow past such shapes are limited in the literature. In a recent paper,[1] Cole and Aroesty have investigated the flow behind concave and convex exponential shock waves within the framework of hypersonic small disturbance theory (HSDT), and have made studies on the optimum shape in the case of concave body.

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