Engineering Notes

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Effect of Sweep Angles on Aerodynamic Performance of Double Arrow Wing—An Analytical Study

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Nomenclature

b	= wing span
$b(x)$	= local wing span
$\bar{c}$	= mean aerodynamic chord
c_{r_1}	= axial distance between leading-edge breakpoint and trailing-edge tip
c_{r_2}	= axial distance between apex and leading-edge breakpoint
C_L	= lift coefficient
C_m	= pitching moment coefficient
D	= drag
L	= lift
M	= Mach number
x,y,z	= body axis coordinates
x_1	= axial distance measured from leading-edge breakpoint
α	= angle of attack
ΔC_D	= drag due-to-lift coefficient
ΔC_p	= difference between upper and lower surface pressure coefficients
Λ_{in}	= inboard leading-edge sweep angle
Λ_{out}	= outboard leading-edge sweep angle

Introduction

THE strake-wing configurations are hybrid wing planforms which have been studied (for example, Refs. 1-6) with a view to adopt them on supersonic transport and fighter planes. The general advantages of using such complex planforms are a better aerodynamic center control with Mach number changes, utilization of vortex lift, and maneuverability.

Much of the previous work on the strake-wing configurations has been of experimental nature. In the present work, an analytical approach is used to study the effect of the leading-edge sweep angles on the aerodynamic performance of an arrow wing with a strake. The method employed for this purpose is the free vortex sheet (FVS) method[7] developed by Boeing Aircraft Company under a contract with NASA Langley Research Center. The method is based on a three-dimensional inviscid flow model. This is an advanced panel method using quadratic doublet distributions to represent the wing surface, the rolled up vortex sheet, and the wake. It is capable of computing forces, moments, and the surface pressures. It has been tested[8,9] and found to predict aerodynamic results satisfactorily up to moderate angles of attack for various configurations.

Results and Discussion

The basic strake-model considered here is a double arrow wing which has an 80 deg inboard sweep, 65 deg outboard sweep, pointed tip, and 30 deg trailing-edge sweep with a

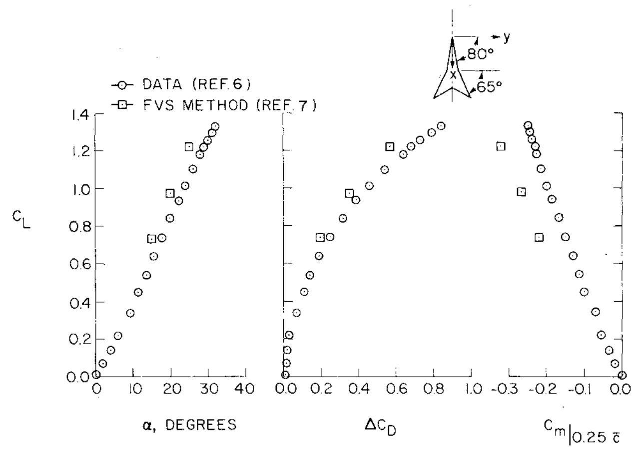

Fig. 1 Comparison of longitudinal aerodynamic characteristics of double arrow wing at $M = 0$.

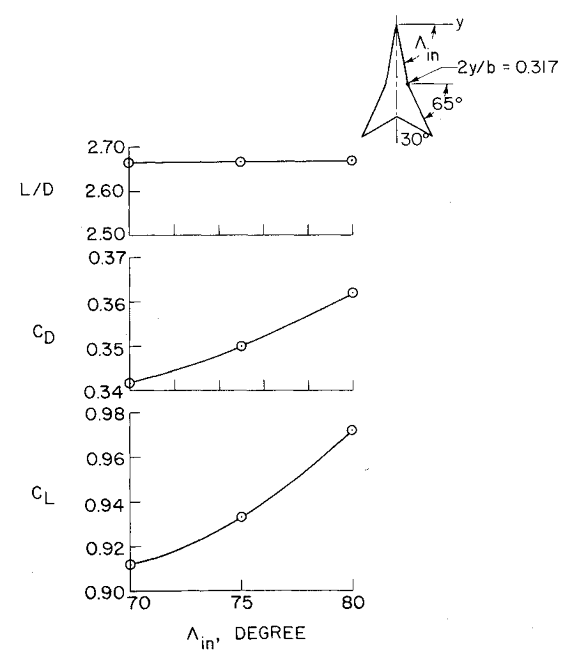

Fig. 2 Effect of inboard leading-edge sweep on aerodynamic characteristics of double arrow wing at $\alpha = 20$ deg and $M = 0$.

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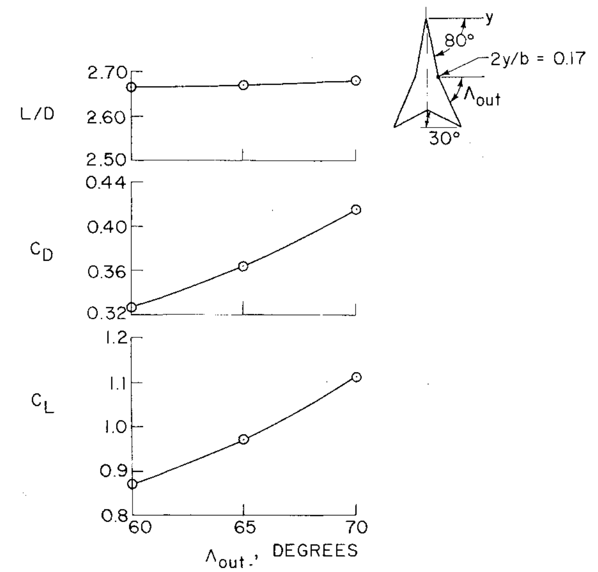

Fig. 3 Effect of outboard leading-edge sweep on aerodynamic characteristics of double arrow wing at $\alpha = 20$ deg and $M = 0$.

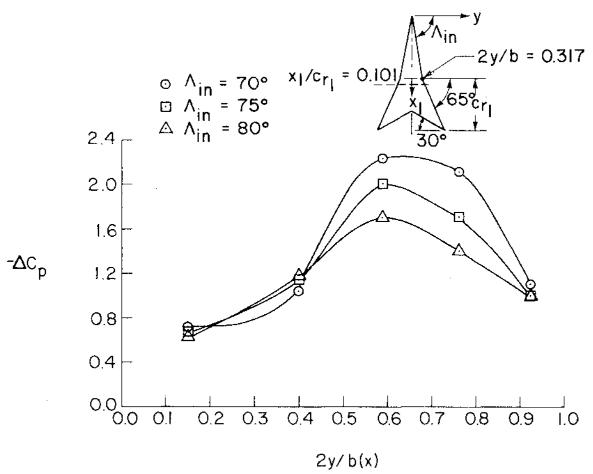

Fig. 4 Effect of inboard leading-edge sweep on spanwise pressure distributions for double arrow wing at $x_I/c_{r_I} = 0.101$, $\alpha = 20$ deg, and $M = 0$.

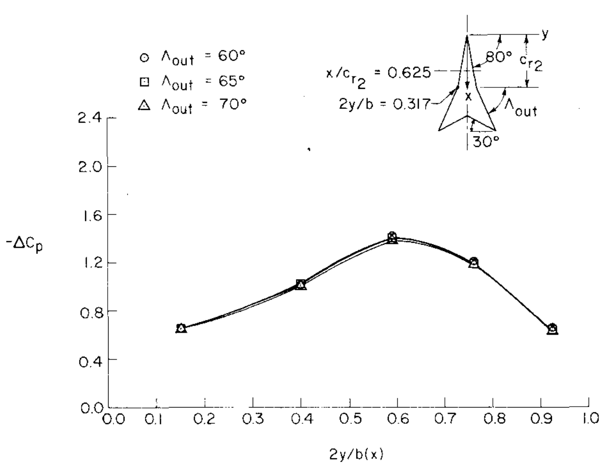

Fig. 5 Effect of outboard leading-edge sweep on spanwise pressure distributions for double arrow wing at $x/c_{r_2} = 0.625$, $\alpha = 20$ deg, and $M = 0$.

break on the leading edge at 0.317 of the span. The inboard and outboard sweep angles have been systematically varied, and the FVS method has been applied to model these modified configurations. The area of the basic configuration is taken as the reference area in calculating the various aerodynamic characteristics of these wings.

In order to evaluate the accuracy of the method used, the experimental data and the predicted results are compared in Fig. 1. The agreement between them is fairly good.

Figures 2 and 3 show the effect of the inboard and outboard leading-edge sweep angles, respectively, on the longitudinal aerodynamic characteristics of the double arrow wing. The lift and drag increase with the increase of these sweep angles, but the lift-to-drag ratio remains essentially constant.

Figure 4 shows the effect of the inboard sweep angle of the leading edge on the spanwise surface pressure distributions in the aft region of the wing. The effect is considerable. The net pressure generally decreases as the inboard sweep angle increases. However, the pressure peak occurs almost at the same location on the wing indicating that the inboard sweep angle has little effect on this pressure peak location. The effect of the outboard sweep angle of the leading edge on the spanwise pressure distributions in the forward region of the wing is very small as illustrated by Fig. 5.

Conclusions

The lift and drag increase with the increase in the inboard and the outboard leading-edge sweep angles of a double arrow wing. However, the lift-to-drag ratio is little affected by the changes in these sweep angles. The spanwise surface pressure distributions in the aft region of the wing are considerably influenced by the inboard sweep angle, whereas the outboard sweep angle has no discernable effect on these pressures in the forward region of the wing.

Acknowledgments

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