Shape Memory Alloy Actuated Macro-scale Morphing Aircraft Mechanisms

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Using NASA Langley's Hyper-Elliptical Cambered Span (HECS) variable geometry wing as a testbed, a morphing wing mechanism was developed capable of varying the dihedral of the wing in a discretized approximation of a continuous spanwise curvature. The theoretical wing, inspired by the shape of shore birds such as the albatross, promises a reduction in induced drag compared to an elliptical wing of up to 5% based on its crescent-like planform shape, while decreases the lift-to-drag ratio by up to 15% over a wide flight regime based on the span decrease. For certain angles of attack, however, this effect is lessened by an overall efficiency factor change due to a nonplanar vortex wake as an the morphed wing functions as effective winglet. Quasi-static wind tunnel tests confirm the theoretical expectations for an ideal HECS wing shape before a final morphing mechanism is implemented. This mechanism utilizes shape memory alloy to affect the spanwise curvature, and uses a power source that can be flown on a UAV-scale aircraft. Successful dynamic morphing wind tunnel tests of the final mechanism confirm the feasibility of this design, indicating a change in lift-to-drag ratios over a range of angle of attack comparable to that predicted by the continuous wing. Future applications of comparable mechanisms in the form of a chiroptera-inspired (bat-wing) aircraft will be discussed.

Nomenclature

b'	=	morphed projected span
k	=	spanwise efficiency factor
A	=	aspect ratio
ψ	=	span ratio factor
β	=	spanwise camber factor
d	=	change in Z component of tip relative to root during morph
V_{in}	=	input voltage
L	=	motor inductance
I_{in}	=	input current
R	=	motor resistance
k_e	=	motor electrical constant
k_t	=	motor torque constant
J_a	=	motor armature mass moment of inertia
J_L	=	motor load mass moment of inertia
θ_{root}	=	angle of proximal section relative to fuselage about X axis
T_f	=	motor frictional torque
T_L	=	torque dissipated by load

I. Introduction

THROUGHOUT the history of conventional aircraft design, the majority of aircraft have each fulfilled one primary goal. In order to maximize efficiency, vehicles were developed with particular cruise configurations and fixed wings, with minimal amounts 'morphing' devices. These morphing elements consisted of components

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