47th AIAA Aerospace Sciences Meeting Including The New Horizons Forum and Aerospace Exposition
5 - 8 January 2009, Orlando, Florida

AIAA 2009-1435

Camber Controlled Airfoil Design for Morphing UAV

Cody Lafountain[1], Kelly Cohen[2] and Shaaban Abdallah[3]

University of Cincinnati, Cincinnati, OH, 45221

Morphing technology, inspired by bat and bird flight, can enable an aircraft to adapt its shape to best suit the flight condition thereby enhancing mission performance. In this paper, we propose a camber change for the morphing of airfoils with the aim of improving aerodynamic efficiency. The Global Hawk UAV mission in general and its LRN1015 airfoil in particular is in focus due to the relative long mission times spent at the two different flight conditions, namely high-speed dash and low speed loiter. Specifically, we are in search of the basic relationships between flap deflection and airfoil morphing based on a camber change. We are using several tools to virtually simulate a morphing wing including XFOIL to perform fast and relatively accurate two-dimensional steady-flow simulations of different morphed configurations using a camber controlled morphed wing to maneuver. Results show that for the LRN1015 airfoil, we can achieve the lift differential required to perform a maneuver while maintaining higher efficiency than an aircraft using flaps to perform the same maneuver.

Nomenclature

C_l	=	lift coefficient	c	=	chord
C_d	=	drag coefficient	*M*	=	Mach number
C_p	=	pressure coefficient	*Re*	=	Reynolds number
FEM	=	finite element model	*CFD*	=	computational fluid dynamics

I. Introduction

DURING the past two decades, there has been a growing need for aircraft to perform effectively while flying in aerodynamically different operating regimes within the flight envelope during a single mission. Wing morphing/shape shifting technologies can empower aircraft (manned and unmanned) to adapt its aerodynamic configuration “on demand”, thereby expanding their role and capabilities in the tactical arena. In recent years there has been an increasing number of academic, government and industrial interest in morphing technology[1-7]. A fine example of effective morphing in a flying creature is the Bat. Bats have very efficient wings, and they have a unique ability to morph wing camber. Morphing (changing camber and aspect ratio) makes bats far more maneuverable than birds especially at very low speeds. Bats’ wings consist of long, thin, lightweight bones, held together by a skin membrane, which enables the rapid change in wing camber. Using the Bat as the biological inspiration behind the proposed research program, we develop an approach for morphed camber control which enables maneuvering without the conventional control surfaces.

This effort is part of the Morphing Wing program at the University of Cincinnati. In this program, we develop experimental and computational tools to aid in the development of aerodynamic, structural and control technologies that allow air vehicles to maintain a safe and effective transition during in-flight morphing maneuvers in dynamic environments. The main objective of the program is to develop a computational tool that predicts the dynamic response to various control inputs, including large strain shape memory alloy actuation as well as high frequency piezo-ceramic actuators, for a morphing wing of a high-performance aircraft. The ultimate goal is to design an effective closed-loop structural control methodology to maintain/augment maneuvers using morphing of the airfoil camber. The uniqueness of this program lies in the coupling of various morphing modes such as airfoil shape, sweep

[1] Undergraduate Student, Dept. of Aerospace Engineering, P.O. Box 210070, Student Member
[2] Associate Professor, Dept. of Aerospace Engineering, P.O. Box 210070, Associate Fellow
[3] Professor, Dept. of Aerospace Engineering, P.O. Box 210070, Member

Copyright © 2009 by the American Institute of Aeronautics and Astronautics, Inc. All rights reserved.