A VARIABLE STIFFNESS SKIN FOR MORPHING HIGH-LIFT DEVICES

G.A.A. THUWIS, M.M. ABDALLA and Z. GÜRDAL

Aerospace Structures,Delft University of Technology, Kluyverweg 1,
Delft, 2629HS, The Netherlands
g.a.a.thuwis@tudelft.nl
http://www.lr.tudelft.nl/aes

Abstract

Seamless morphing structures are a possible solution for the next generation of smart high-lift devices. The present work presents a passive composite variable stiffness skin as a solution to the dilemma of having a high stiffness to withstand aerodynamic loading, and low stiffness to enable morphing. Such a variable stiffness skin is achieved by a spatial fibre angle and skin thickness variation. The tailored stiffness distribution beneficially influences the structural deformation. A realistic skin stiffness is designed while taking the actuation and varying aerodynamic loads into account. A two-dimensional aero-servo-elastic framework is created for this purpose. Skin stiffness optimisation can be done either by using an existing actuation topology, or by using a linear topology optimisation routine using the Simple Isotropic Material with Penalisation (SIMP) approach. This paper addresses the implementation of the aero-servo-elastic framework and the topology optimisation routine. Results for a skin stiffness distribution with an existing actuation system and a combined skin stiffness/actuation topology design are presented. Results indicate that a variable stiffness skin increases the design space. Moreover, the included topology design is a valuable aid in the determination of an improved actuation topology.

Keywords SADE; morphing; high-lift; optimisation; SIMP; aeroelasticity.

1. Introduction

Aerospace engineers are on a never ending quest in search of new technologies or improvements to current techniques to enable the design of a more economical and ecological next generation airplane. A solution to the problem of the ever decreasing amount of fossil fuels is to find ways to use the existing amount in a more economical fashion. Tasks enabling to preserve the fuel reserve until alternative fuels are mature enough to replace fossil fuels. Moreover, airplane operators would like to keep operation costs as low as possible to be able to compete with the expanding market of low cost carriers.

Wing morphing techniques allow the adaptation of the wing geometry such that the wing performance is maximised for each part of the flight. Such improvement could for example be a drag reduction at certain stages of a flight which leads to a lower fuel consumption and the associated cost reduction. The current implementation of high-lift systems with slats and flaps are an example of such a morphing system since the wing geometry is adapted to enable the increase in lift at a reduced velocity.

A deployed leading edge slat creates a gap between the slat and the main wing. Such a gap is a cause of increased drag and is moreover a source of noise (Pott-Pollenske *et al.*, 2006). Within the FP7 project "Smart High Lift Devices for Next Generation Wings" (SADE), a seamless alternative to these slotted systems is sought (SADE, 2009). Such an improvement would increase the economical and ecological performance of current high-lift systems.

Ever since the application of wing twist on the Wright Flyer I in 1903 (Wright, 1953), morphing systems have emerged which can accomplish a wide range of shape changes. Such morphing structures are commonly divided into three categories depending on the scale of the morphing structure:

- large scale morphing related to changes in wing area, span and sweep;
- medium scale morphing with changes in camber, twist and airfoil shape;
- small scale morphing to alter the local airfoil.