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A composite wing structure with morphing leading edge and FLAP

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Abstract

This current paper presents a study on the design and analysis of a composite wing box with a morphing leading edge (LE) and flap structure and actuation devices. The effect of the aerodynamic pressure load on the structure and device design was also considered. Firstly, a thin-walled composite wing box structure model was created for design and parametric study. A 2D and 3D analysis was then carried out to evaluate the effect of the LE stiffness on the overall wing rigidity. This investigation showed that the leading edge local stiffness could be reduced for large elastic deformation without significant effect on the overall wing rigidity. The subsequent nonlinear structural modelling and analysis of the morphing LE and flap trailing edge was carried out. The results showed that the proposed actuation mechanism is simple and feasible to achieve the required wing LE and flap morphing shape. Therefore it has the potential to be applied to an actuation system for the high lift devices of a large aircraft wing.

Key words: *Composite wing box, High lift device, Actuation mechanism, Morphing leading edge, Morphing flap*

1. Introduction

At present an aircraft is often designed to gain optimised performance in a certain flight condition. By developing and employing morphing wing technology, it would be possible to achieve an optimal aerodynamic performance in a wide range of the flight envelop. Several projects (Pendleton *et al.*, 2002; Heeg *et al.*, 2005; Voracek *et al.*, 2003; Kuzmina *et al.*, 2002; Schweiger *et al.*, 2002) have focused their attention on the development of adaptive wing concepts by varying the wing shape spanwise and/or chordwise. For a commercial aircraft, a wing with morphing high lift surfaces and devices would have more potential benefits but face more challenges to achieve at least the same performance obtained by the current airframe. Aerodynamically a wing with morphing high lift devices has the potential to reduce drag and noise from open gaps during the device deployment or operation (Bolonkin and Gilyard, 1999; Szodruch and Hilbig, 1988). It also has the potential to reduce the overall airframe weight and complexity. In previous research, several concepts have been developed for morphing trailing edge (Perera and Guo, 2009; Ricci *et al.*, 2006; Campanile and Anders, 2005; Monner *et al.*, 1999; Cho *et al.*, 2004) and leading edge (Monner *et al.*, 2009; Rowarth and Cave,

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