ROBUST AEROELASTIC TAILORING FOR COMPOSITE AIRCRAFT WINGS

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Abstract

There is much current interest in the use of composite materials for aircraft structural design. Although the possibility of aeroelastic tailoring has been around since the early 1980s, most applications of CFRP have been “black metal” designs which do not exploit the anisotropic properties. One possible reason for the delays in designing aeroelastically tailored aircraft structures is the explosion in the number of design variables that occur. A further consideration is the effect of uncertainty on the entire design process which could be used to develop robust optimum designs.

In this paper, an optimisation framework is developed for the robust design of composite aircraft wings through consideration of uncertainties in ply orientations and thicknesses. A detailed Finite Element wing box model of a regional jet airliner is used as a benchmark. The wing structure is optimised for minimum weight with stress, buckling, flutter/divergence and gust root bending moment constraints. Lamination parameters are utilised to account for bend-twist coupling in the structure. Input loads for the weight optimisation are derived across the desired flight envelope. The Polynomial Chaos Expansion approach is used to efficiently quantify the effects of uncertainty in the design parameters. This method is used to determine and minimise the probability of flutter/divergence occurring, and the allowable root bending moment being exceeded, for any given design specification.

Ant Colony Optimisation (ACO) is employed for the overall optimisation procedure. The efficiency and reliability of the approach is assessed through comparison with Genetic and Particle Swarm Optimisation algorithms. The trade-offs due to the choice of different weighting coefficients for constraints in the objective function are investigated along with amount of computation required and ease of use.

Results show that the proposed approach can provide an efficient method for the optimisation and robust design of an aircraft composite wing, subject to aeroelastic and structural constraints. The use of ACO algorithms is shown to be a computational efficient option.

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