Krupa, E., Cooper, J., Pirrera, A., & Silva, G. H. C. (2016). Aeroelastic Tailoring for Enhanced Aerodynamic Wing Performance. In 5th Aircraft Structural Design Conference. Royal Aeronautical Society.

Aeroelastic Tailoring for Enhanced Aerodynamic Wing Performance

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This study investigates the use of a novel aeroelastic tailoring design methodology for the optimisation of aircraft performance. An optimisation framework which integrates static and dynamic aeroelastic analyses with the optimisation of blended laminates has been developed. The framework uses an inverse design method to find the lightest composite structure that attains a desired aerodynamic shape, whilst also meeting a number of structural and aeroelastic constraints. A bi-level approach, integrating gradient-based and particle swarm optimisations, is used to tailor the wing structure at stringer bay level and to obtain feasible and detailed stacking sequences for the composite wing skin. The tailoring capabilities offered by composite materials are benchmarked in terms of aeroelastic performance by comparing optimised solutions against an all-metallic wing obtained with the same methodology. Two different design studies are performed: the first one minimises mass only. The second minimises the difference between a target aerodynamic shape and deformed wing shape in terms of local twist distributions. Optimisation design variables include: thicknesses of the metallic and composite panels; composite lamination parameters; position, orientation and spacing of stringers and ribs. Constraints on maximum allowable stresses, maximum deflections, flutter speed and buckling are considered, together with composite manufacturing guidelines. Results for multiple manoeuvres and cruise load cases are presented. It is shown that the proposed approach enables aerostructurally efficient solutions to be found using a representative civil jet aircraft wing.

Keywords: passive aeroelastic tailoring, composite optimisation, jig-shape, induced elastic twist.

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