A coupled framework for analysis and optimization of an aeroelastically tailored wing skin

N. Abdollahi[*], A. Totounferoush[†], H.R. Ovesy[‡]

[*] Aerospace Engineering Department and the Center of Excellence in Computational Aerospace Engineering, Amirkabir University of Technology, Tehran, Iran, nadia73@aut.ac.ir

[†] University of Stuttgart, UniversitatStr. 38 D-70569, Stuttgart, Germany, amin.totounferoush@ipvs.uni-stuttgart.de

[‡] Aerospace Engineering Department and the Center of Excellence in Computational Aerospace Engineering, Amirkabir University of Technology, Tehran, Iran, ovesy@aut.ac.ir

ABSTRACT

Aeroelastic tailoring is typically known as the utilization of the directional stiffness properties of a structure to control its aeroelastic deformations in a favorable manner. The aircraft's operational efficiency can be significantly improved by taking advantage of the anisotropic properties of composite materials in the wing's structure. Having a coupled analysis and optimization framework enable us to investigate different aspects of such a complex structure and design it in a way that meets the aeroelastic requirements. Therefore, we present an aeroelastic tailoring and optimization framework for a contemporary aircraft's composite wing model, namely the NASA Common Research Model (CRM).

We use Open-Foam solver to simulate the fluid part and Calculix solver for structural analysis, while preCICE coupling library is used to couple these two solvers. The preCICE library provides data exchange between solvers, equation coupling and data mapping between meshes in case of non-matching grids. This gives us big flexibility for choosing the solvers, mesh type and coupling scheme for different scenarios. The framework includes both static and dynamic aeroelastic models. In the static analysis, the geometrically nonlinear structural model is coupled with the steady-state aerodynamic model. The dynamic aeroelastic analysis, however, consists of a linearized dynamic structural model together with an unsteady aerodynamic model. The wing is discretized along the span into several sections, each having different stiffness and thickness in order to fully tailor the wing for minimum weight while taking into account multiple constraints including the aeroelastic stability, strength, buckling and the aileron effectiveness.

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