RELIABILITY-BASED DESIGN OPTIMIZATION OF A COMPOSITE PLATE THROUGH A DUAL DESIGN SPACE

L. Coelho[1*], N. Fabbiane[1], C. Fagiano[1] , C. Julien[1], and D. Lucor[2]

[1] ONERA, The French Aerospace Lab, Châtillon, France
[2] LIMSI-CNRS, Orsay, France
[*] ludovic.coelho@onera.fr

Aeroelastic phenomena play an important role in the design of an aircraft and their sensitivity to structural and operating parameters makes them susceptible to uncertainties [1]. Both the geometrical tolerances in the fabrication process and the inherent scattering of the material properties call for aleatory uncertainty quantification. Diaz et al. [2] proposed an efficient methodology to perform reliability-based design optimization of complex composite structures with random design variables, i.e. the ply thicknesses. Within the aeroelastic community, Scrath and Cooper [3] investigated the minimisation of the probability of the flutter instability, modelled as Gaussian processes, in a simple, composite-plate wing: this time, the random design variable were the ply orientations. Even if the resulting design is in some sense an *optimised* solution with respect to the onset of the flutter instability, the proposed procedure is far to be representative of the real aircraft design process since the aeroelastic stability has to be taken into account as a constraint instead of an *improvable* objective.

The objective of this work is to present a strategy where the aeroleastic stability is taken into account as an additional constraint to the structural optimisation process and, similarly to [3], the uncertainty is introduced directly on the design variables, namely the ply orientations. The optimisation procedure relies on the homogenised description of the stacking-sequence given by the *lamination parameters* to (i) avoid the dependency of the number of design variables by the stacking-sequence and (ii) benefit from a smoother behavior of the functions of interest. On the one hand, the choice of working with two connected design spaces – i.e. the stacking-sequence and the lamination parameters – enables the use of a convenient gradient-based optimisation algorithm. On the other hand, this choice presents further challenges related to the the inverse mapping problem, i.e. the identification of the ply orientations from their homogenised description. Indeed, the quantification of the failure probability requires to precisely retrieve the stacking-sequence in order to propagate the orientations uncertainty to the constraint functions.

This approach is illustrated and validated on the optimisation of a composite plate where the bending stiffness is maximized ensuring a limit probability on the buckling factor of the plate. A more computationally expensive constraint on the aeroelastic stability of the plate will be also considered by constraining the probability of exceeding a given critical flutter-velocity.

References

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