Structural optimization of a wing body with uncertain aerodynamic loads

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ABSTRACT

An algorithm for the structural optimization of wing bodies is presented in this paper. The structural analysis for the computation of displacements and stresses within the wing body is based on a finite volume solver of the OpenFOAM software. The topology optimization is based on the original methodology proposed in [1], including the SIMP algorithm, the smoothing of computed fields using the solution of the Helmholtz equation and the optimization procedure. This is applied to solve the minimum compliance problem in a wing in order to compute the optimal distribution of material within the wing body that maximizes its stiffness constrained by a user defined volume. The loading is based on the forces acting upon the wing body due to aerodynamic pressure and stress distributions.

The study moves a step further from the single point structural topology optimization by considering the uncertainties in both the loading and the parameters of the wing model. The optimization is robust since the minimization of the mean value and standard deviation of the compliance is sought with respect to these uncertainties and also reliable by imposing a constraint on the probability the total volume exceeds a certain value.

The topology optimization algorithm is self-adjoint and the uncertainties with respect to the loading and model parameters are dealt with a sparse grid methodology for robust design and the FORM method for reliability-based optimization [2]. The methodology is applied to the robust and reliability-based topology optimization of a swept wing body.

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REFERENCES

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