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Structural design of aircraft wing based on topology and global-local optimization

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Abstract

An approach to structural design based on topology and global-local optimization is proposed. It exploits the mathematical models of different fidelity. Solid model is used for topology optimization, shell/beam model – for structural sizing on global level, refined panel model – for detailed sizing on local model, aerodynamic model – for loads and aeroelasticity analysis. Structural design procedure is described. Main features concerning the stated global-local optimization problem is discussed. The global-local approach for structural analysis and optimization based on using mathematical models of different fidelity has been presented by authors in recent paper [1]. The aim of this work is to combine topology optimization with the structural optimization based on the global-local approach to perform a complete design procedure of aircraft structures.

Topology optimization allows to determine the principal load-carrying directions in which structural material should be located. These directions are strongly related with the way of load application and number of load cases. The article discusses influence of these factors on the final topology layout. Usually various engineering interpretations of the topology optimization results can be done by designer. In the proposed approach we generate several structural layouts for which the global-local structural optimization is performed.

Stress analysis is performed on the global finite element model which generally does not include refined meshes. They are used in local finite element models for more detailed simulation of buckling of separate structural components such as wing panels. The relation between global and local models is fulfilled by the transfer of stress resultants obtained on the global model to the local models of structural panels. Also the boundary conditions for a local model should be correctly defined by use of the global model results. This paper describes the approach for realization of this relation between mathematical models of different fidelity. Also main features concerning the stated global-local optimization problem are given in the paper.

After the stress/buckling optimization the aeroelasticity analysis is accomplished and some changes to structural parameters are fulfilled to meet flutter and divergence requirements. Comparison of obtained optimum masses gives possibility to find the best structural layout of wing. The approach is demonstrated on the example of design of low-aspect-ratio wing of advanced helicopter.

References

[1] V.V. Chedrik, S.A. Tuktarov, Optimization of Composite Structures Based on Global-Local Approach, International Conference on Engineering and Applied Sciences Optimization (OPT-i), Kos, Greece, 2014 (ISBN:978-960-99994-5-8).