6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

Simultaneous density and anisotropy optimization of 3D structures made of transversely isotropic materials

N. Ranaivomiarana[1], F.-X. Irisarri[1], D. Bettebghor[1] and B. Desmorat[2]

[1] Onera FR-92322 Châtillon, France,
{narindra.ranaivomiarana,francois-xavier.irisarri,dimitri.bettebghor}@onera.fr
[2] Sorbonne Université, Centre National de la Recherche Scientifique, UMR 7190,
Institut Jean Le Rond ∂'Alembert, F-75005 Paris, France, boris.desmorat@upmc.fr

Keywords: *Topology optimization, SIMP, distributed anisotropy, material design*

This project is funded by STELIA Aerospace. Reducing weight and costs of structures is of great importance for aeronautic industry. Topology optimization is a first response to this concern as it consists of determining the best shape of a given structure. There are lot of works for isotropic materials, much less for anisotropic materials such as composite ones although they are lighter. Composite optimization aims at designing the material anisotropy behavior. The anisotropy distribution is optimized with a predefined shape, in most cases with the preexisting metallic parts. Nevertheless, such a practice is questionable since the material anisotropy influences the optimal shape. This project aims at developing a simultaneous optimization method of topology and anisotropy distribution for 3D structures. This work takes advantage on a recent methodology developed in 2D to solve a compliance minimization problem with a maximal volume constraint. An optimality criteria algorithm called alternate directions algorithm [1] is used to solve the numerical problem. The procedure iterates between local minimizations in each element with fixed stress and re-actualization of the stress field with fixed design variables by performing a finite element analysis. The SIMP method [2] is used to parameterize the material density distribution. The distributed anisotropy is parameterized by its elasticity tensor invariants by change of frame. In 2D, the polar invariants are used [3]. In 3D, significant work has been done to identify the adequate invariants and to solve the local minimizations. The optimal orientation of the transversely isotropic material is found to be aligned with the same direction as the highest absolute eigenvalue of the stress tensor's deviator. Academic and industrial test cases are presented.

REFERENCES

[1] G. Allaire, R. V. Kohn. *Optimal design for minimum weight and compliance in plane stress using extremal microstructures*, European Journal of Mechanics - A/Solids, Elsevier, 839-878, 1993.

[2] M. P. Bendsøe. *Optimal shape design as a material distribution problem*, Structural Optimization, Springer-Verlag, 193-202, 1989.

[3] G. Verchery. *Les invariants des tenseurs dordre 4 du type de l'élasticité*, Mechanical Behavior of Anisotropic Solids, Springer, 93–104, 1982.