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

OFFLINE PRE-PROCESSING IN MICRO-ARCHITECTURE DESIGN OF COMPOSITES

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Key Words: *Inverse elastic homogenization, Topology optimization, Symmetry, Database.*

The objective of this work is to study new methodologies to make easier the finding of simple micro-architecture solutions of composites whose effective elasticity tensors have to be identical to given target tensors. As it is shown in the literature, this problem can be attacked by using topology optimization techniques. However, the techniques described in the literature take into account only few, if any, symmetry considerations of the target elasticity tensors.

The premise of this work consists on supposing that an adequate unit cell shape, i.e. the domain where the topology optimization problems is posed, makes easier to find a simple micro-architecture solution. The use of geometrical symmetries can simplify the problem.

Based on these symmetries we can choose adequate unit cell shapes and we can impose restrictions to the internal distribution of material in these cells. However, a symmetry analysis of the target tensor deals with rather general relationships between its coefficients, e.g. if they are zero or if two of them are equal. Therefore, just considering symmetry is not enough to give a complete description about the best aspect ratio of the unit cells. Additionally, symmetry does not give a hint about how to choose the most convenient initial configuration of the composite to initialize the topology optimization algorithm.

Taking into account the above considerations, in this work we present a procedure that consists on an offline calculation of the homogenized elastic tensor for several composite classes, for many volume fractions, and for all the possible Voronoi cells in 2D. Having this database at disposal, we make a search within it to find the homogenized tensor that better approximates the target tensor. As a result, we have the best possible shape of the unit cell and the more suitable initial material distribution to start the optimization algorithm.

For example, if we want to design an orthotropic material, a symmetry analysis says us that we can use a rectangle as a unit cell, but the technique presented here also says about the aspect ratio that the rectangle should have. As another example, if the target tensor has negative Poisson's ratio, a search on the database will certainly find a class of composites with reentrances as the best initial configuration.

We show that this procedure significantly helps to find simple micro-architecture solutions of the topology optimization problem, especially when extreme materials have to be designed.

[1] Méndez, C. et al. (2017). *Computational material design for acoustic cloaking*. Int. J. Numer. Meth. Engng, 112: 1353–1380.

[2] Podestá J. M. et al. (2018). *Material design of elastic structures using Voronoi cells*. Int. J. Numer. Meth. Engng, submitted.