Contribution ID: **82** Type: **Contributed Talk**

Combined topology-parameter multi-material optimization by the topological derivative

Thursday, August 15, 2024 12:00 PM (30 minutes)

We consider a PDE-constrained design optimization problem with multiple materials, where some material properties are defined by an additional parameter. For this problem we derive the topological derivative i.e. the pointwise sensitivity of the cost functional subject to material changes and use it to update a vector-valued level set function describing the material distribution within the design domain. In an additional step we simultaneously optimize the material parameter by minimizing the topological derivative. This we can do either pointwise, resulting in a parameter distribution, or blockwise by averaging the topological derivative. The latter approach would lead to a fixed number of different parameters which could increase the manufacturability of the design. We apply this approach to two engineering problems: First a permanent magnet synchronous electric machine where we optimize not only the design but also the orientation of the permanent magnets and second a cantilever where we parametrized the lattice microstructure of the material.

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Session Classification: MS 12: Innovative Methods for Shape Optimization

Track Classification: Minisymposia: MS 12: Innovative Methods for Shape Optimization