Methods for Topological Design of Conducting Networks

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ABSTRACT

Topology optimization [1] is a computational technique for designing an engineering system optimized for a quantity of interest (e.g energy) subject to a constraint (e.g. some prescribed mass). A popular approach it to use a field approximated by finite elements representing the distribution of material throughout the domain. Formally the behavior of the material under some natural loading is represented by the solution of a PDE state constraint. This is used to realize the quantity of interest (objective) and satisfaction of physical constraints. Given a discretization of the PDE and the material field, a numerical optimizer can be employed to find an optimal distribution of material that satisfies the PDE, the physical constraints, and optimizes the quantity of interest. This talk will explore the numerical methods and optimization formulations used for design of conducting networks in electrical devices.

Recent research has shown that for large scale topology optimization problems, primal-dual interior point (PDIP) methods can offer favorable convergence when compared with mesh-dependent approaches such as the Method of Moving Asymptotes and its variants [2]. In the current work, the interior trust regions method proposed in [3] will be applied to topology optimization problems. Results assessing algorithmic performance, scalability and design quality for several topology optimization problems will be presented.

Coaxial cables, and transmissions lines in general, are critical elements in transmission of high frequency alternating currents over relatively long distances. They appear in modern communications equipment, but also in devices that require transmission of a large amount of current applied over a short period of time. This talk will explore topology optimization formulations for design of coaxial cables with an eye to the requirements of complex high energy devices. These problems can be reduced to the problem of placing conductive material in a void to carry current through the domain between specified in and out ports. Two simplified models of the physics will be considered. The first a electrostatic model is intended to satisfy the basic power flow requirements. The second application model, uses a quasi-static Maxwell formulation to achieve realistic short time current flows.

REFERENCES

[1] O. Sigmund and K. Maute, Topology optimization approaches, *Structural and Multidisciplinary Optimization* 48.6: 1031-1055, (2013).

[2] S. Rojas-Labanda and M. Stolpe, Benchmarking optimization solvers for structural topology optimization, *Struct. Multidisc. Optim.* 52:527547 (2015).

[3] T. F. Coleman and Y. Li, An interior trust region approach for nonlinear minimization subject to bounds, *SIAM Journal on optimization*, 6(2), 418-445 (1996).