Technical University of Denmark

DTU

Topology optimization for transient heat transfer problems

Zeidan, Said; Sigmund, Ole; Lazarov, Boyan Stefanov

DTU Library
Technical Information Center of Denmark

Topology optimization for transient heat transfer problems

Said Zeidan[*], Ole Sigmund, Boyan S. Lazarov

Technical University of Denmark
Department of Mechanical Engineering
Nils Koppels Allé, 2800 Lyngby, Denmark
szeidan@mek.dtu.dk

ABSTRACT

The focus of this work is on passive control of transient heat transfer problems using the topology optimization (TopOpt) method [1]. The goal is to find distributions of a limited amount of phase change material (PCM), within a given design domain, which optimizes the heat energy storage [2]. Our aim is to obtain manufacturable designs [3] as well as demonstrating TopOpt for mixed multiphysics problems [4].

TopOpt provides material distributions in a given design domain, optimized with respect to a given objective and satisfying a set of constraints. Originating in static mechanical problems, TopOpt has later been extended to transient problems in mechanics and photonics (e.g. [5], [6] and [7]). In the presented approach, the optimization is gradient-based, where in each iteration the non-steady heat conduction equation is solved, using the finite element method and an appropriate time-stepping scheme.

A PCM can efficiently absorb heat while keeping its temperature nearly unchanged [8]. The use of PCM in e.g. electronics [9] and mechanics [10], yields improved performance and lower costs depending on a.o., the spatial distribution of PCM.

The considered problem consists in optimizing the distribution of PCM in a design domain, subject to a periodic heat influx. The objective is to stabilize the heat outflow. Application examples include keeping constant room temperature for oscilatory heat input or keeping constant working temperature of a CPU subjected to time varying computational load.

References

[1] M. P. Bendsøe and O. Sigmund, Topology Optimization - Theory, Methods, and Applications. Springer Verlag, 2003.

[2] V. Srinivas and G. Ananthasuresh, "Analysis and topology optimization of heat sinks with a phase- change material on comsol multiphysicsTM platform", Proceedings of the COMSOL Users Conference, 2006.

[3] M. Schevenels, B. S. Lazarov, and O. Sigmund, "Robust topology optimization accounting for spatially varying manufacturing errors", Computer Methods in Applied Mechanics and Engi- neering, vol. 200, no. 49-52, pp. 3613-3627, 2011.

[4] S. Madsen, N. P. Lange, L. Giuliani, G. Jomaas, B. S. Lazarov, and O. Sigmund, "Topology optimization for simplified structural fire safety: an alternative way of imposing length scale", "submitted," 2015.

[5] Y. Elesin, B. S. Lazarov, J. S. Jensen, and O. Sigmund, "Design of robust and efficient pho- tonic switches using topology optimization", Photonics and Nanostructures - Fundamentals and Applications, vol. 10, no. 1, pp. 153-165, 2012.

[6] J. Dahl, J. S. Jensen, and O. Sigmund, "Topology optimization for transient problems in one di- mension: Design of lters and pulse modulators", Structural and Multidisciplinary Optimization, vol. 36, pp. 585-595, 2008.

[7] R. Matzen, J. Jensen, and O. Sigmund, "Topology optimization for transient response of pho- tonic crystal structures", Journal of the Optical Society of America B, vol. 27, no. 10, pp. 2040- 2050, 2010.

[8] A. S. Fleischer, Thermal energy storage using phase change materials : fundamentals and ap- plications. 2015.

[9] F. Kaplan, C. De Vivero, S. Howes, M. Arora, H. Homayoun, W. Burleson, D. Tullsen, and A. K. Coskun, "Modeling and analysis of phase change materials for efficient thermal manage- ment", 2014 32nd Ieee International Conference on Computer Design, Iccd 2014, Ieee Int. Conf. Comput. Des., Iccd, pp. 6974690, 256-263, 2014.

[10] A. Stockwell, N. Neithalath, and S. Rajan, "Multiphysics design optimization model for struc- tural walls incorporating phase-change materials", Engineering Optimization, vol. 47, no. 3, pp. 308-327, 2015.