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Topology optimization for transient heat transfer problems

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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 oscillatory heat input or keeping constant working temperature of a CPU subjected to time varying computational load.

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