11th World Congress on Structural and Multidisciplinary Optimisation
07th -12th, June 2015, Sydney Australia

Topology optimization of vibration energy harvesters using electromagnetic induction

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Abstract

In this work, vibration energy harvesters based on the electromagnetic induction is designed using topology optimization. For the transduction between the mechanical vibration and electric energy through the magnetic field, the harvester is composed of a mechanical coil spring, wires and permanent magnets (PMs) with or without a magnetic back iron. The configuration and geometries of the harvester components are simultaneously designed using the topology optimization approach. The optimization objective is to maximize the root-mean-square (RMS) value of the harvested output voltage. The voltage is calculated using the Lagrange polynomial interpolation with the finite element analysis for the given mechanical vibration. The sensitivity of the objective function is derived using the adjoint variable method. The conventional nodal-density based topology optimization is applied without filtering schemes. The proposed topology optimization approach successfully finds the optimal design of the harvester with or without back iron structure. The optimal design result is compared with the initial benchmark design, and shows the significant increase of the output voltage. Finally, the performance enhancement in the optimal design is physically interpreted.