Robust topology optimization for multi-scale structure considering both thermal and mechanical loadings

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Abstract

A robust topology optimization method is proposed for structures composed of periodic microstructures under thermal and mechanical coupled loads. Considering the random and interval hybrid uncertainties, the robust objective function is defined as a linear combination of the mean and standard variance of the thermo-mechanical performance response under the worst case. In order to efficiently analyze the robust objective function, a unified hybrid uncertainty analysis method based on orthogonal polynomials termed as hybrid orthogonal polynomial expansion (HOPE) is developed for hybrid uncertainty analysis in this work. The sensitivities with respect to the macro and micro design variables for the robust objective function and constraint are then calculated based on the hybrid uncertainty analysis. Numerical examples are provided to verify the effectiveness of the proposed method, and the Monte-Carlo-Scanning (MCS) test is used to validate the numerical accuracy of our proposed method. For comparison purpose, the topology optimizations under deterministic assumptions are also provided for the examples to show the importance of considering hybrid uncertainties. By applying the same hybrid uncertainties, the robust objective function values of the robust design are lower than that of the deterministic design, which shows that the robust design considering uncertainties would provide more robust results.

Keywords: Topology optimization; Robust design; Thermo-mechanical; Random and interval hybrid uncertainties