Methodology for the robust design of a network of dynamic vibration absorbers

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Abstract

The proposed work aims to provide a framework for the robust design of devices composed of a network of dynamic vibration absorbers known by the acronym MTMD (Multiple Tuned Mass Damper). The studied case is related to an aeronautic structure hosting a set of optronic devices sensitive to vibrations. This structure has a vibration mode that can be an issue in the frequency band of use that why the mitigation strategy is based on the implementation of an MTMD.
Firstly, a deterministic optimization based on the minimization of the elastic strain energy around the mode of interest is carried out in order to obtain an optimal frequency distribution of the MTMD. The influence of the number of absorbers composing the MTMD as well as the structural damping of the absorbers and their mass on the performance of the optimal solution is presented.

Moreover, this type of device is known to be sensitive to frequency tuning and it turns out that the eigenfrequency of the vibration mode of interest can be considered as a lack of knowledge during the operating cycle of the aeronautic structure. In this context, an epistemic uncertainty is introduced to represent this lack of knowledge. A robustness analysis based on the Info-Gap method, developed by Yakov Ben-Haim since the 1990s, is then implemented to quantify the performance of MTMD according to this source of uncertainty. The performance metric is constructed as the ratio between the elastic strain energy in the structure without MTMD and that with MTMD on the frequency band of interest. The influence of certain parameters on the robustness of the optimal solution is also studied.
Finally, a robust optimization procedure based on deterministic optimization and Info-Gap robustness analysis is proposed in order to make the optimal adjustment of the MTMD insensitive to the lack of knowledge considered over a certain range of variation. This methodology makes it possible to propose a distribution law of the absorbers of an MTMD guaranteeing the robustness of the network for a given horizon of uncertainties.

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