Broadband vibration damping of a non-periodic plate by piezoelectric coupling to its electrical analogue

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ABSTRACT

Several solutions for multimodal vibration damping of thin mechanical structures based on piezoelectric coupling have been developed over the years. The first solutions were based on an extension of the classical resonant shunts to multi-resonant shunts, involving one or several independent piezoelectric patches. Then, the concept of vibration damping by connecting a structure to an electrical network with similar modal properties was suggested in [1]. The practical demonstration of the effectiveness of this method for rods, bars and plates is quite recent [2]. Going forward, the goal is to develop analogous electrical networks for more complex structures, and to be able to predict the damping performance by numerical simulations. Hence, the first objective of this work is to develop a predictive model of a structure connected to an electrical network. The second one is to apply to a non-periodic structure the concept of multimodal damping by piezoelectric coupling to an analogous electrical network.

In this work, the design of a plate electrical analogue is briefly explained and is applied to a simply supported plate. The plate electrical analogue is experimentally validated by visualizing the shapes of the electrical current's distribution. Then, a finite element model of the plate coupled to its analogous network by piezoelectric patches is developed. The modelling follows the method presented in [3]: the basic equations and hypothesis are recalled before formulating the model in terms of displacement and voltage. At last, the interconnection of the patches via an electrical network is considered. The model is validated by comparing numerical and experimental results. Finally, the concept of multimodal damping by piezoelectric coupling to an electrical analogue is extended to a non-periodic plate. The modal properties of the plate are modified by adding local masses on the structure. It is shown that the damping performance is maintained if the electrical network is modified in a similar way to the plate. Furthermore, the finite element model previously developed can predict the dynamics of the electromechanical system. This result is a step towards the development of electrical analogous networks for vibration damping of geometrically complex structures.

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