Effect of adhesive layer properties on the energy harvesting performance of a plate with topologically optimized networks of piezoelectric patches

Jelder Q. Velasquez and Marcelo A. Trindade

Department of Mechanical Engineering, São Carlos School of Engineering, University of São Paulo, Av. Trabalhador São-Carlense, 400, São Carlos, SP, 13566-590, Brazil
Email: jequive@usp.br, trindade@sc.usp.br

ABSTRACT

Piezoelectric patches adhesively bonded on the surface of a vibrating structure are widely employed in micro power generation to study and design piezoelectric energy harvesting circuits, which provide self-generating energy capabilities to electronic devices [1]. This way, it is possible to use them independently from an external power supply. A key parameter of these harvesting devices is the efficiency to convert vibration induced strain energy into electrical energy. Some of the aspects that need to be taken into account when improving the efficiency of energy conversion are: a) proper modeling of the electromechanically coupled device; b) variation of important parameters such as piezoelectric patches shape and geometry; c) inclusion of properly designed electric circuits to improve energy harvesting; and d) distribution of the piezoelectric patches over the structure. The optimization method should simultaneously include all of those parameters to guarantee the best operation conditions since these applications are strongly dependent on the tuning between the harvesting circuit and operating frequencies and on the effective electromechanical coupling between patches and host structure. Therefore, some aspects affecting the mechanical coupling between the piezoelectric patches and the host structure, such as bonding effectiveness, may have major effect on the expected or predicted performance of such devices, due to the potential reduction of mechanical transmissibility between a piezoelectric patch and the host structure [2]. This work investigates the effect of the adhesive layer properties (stiffness, thickness and thickness non-uniformity, for instance) on the performance of topologically optimized networks of piezoelectric patches surface-mounted on a rectangular plate. Results were obtained using a previously developed finite element model that considers two different types of deformation theories [3]. While a plate model considering a First-Order Shear Deformation Theory (FSDT) is used for the host structure, the adhesive layer and the piezoelectric patches are modeled using 3D solid linear elements. The distribution of piezoelectric patches is optimized in order to maximize the energy conversion capability for different total added volume constraints. Then, for the optimal configurations, the effect of variations in adhesive layer material and geometric properties on the energy harvesting performance is evaluated.

REFERENCES

