XVII International Symposium on Dynamic Problems of Mechanics - DINAME 2017
March 5th to 10th, 2017
Beach Hotel Cambury & Sunset, São Sebastião, SP, Brazil

Use of Piezoelectric Materials in Energy Harvesting Systems as Sensors and Actuators

Aline S. De Paula[1], Marcelo A. Savi[2], Wescley O. V. Barbosa[1], Tiago L. Pereira[1], Adriano T. Fabro[1], Daniel S. C. Nieto[1]

[1]Universidade de Brasilia, Departament of Mechanical Engineering, 70.910.900 - Brasília - DF, Brazil, alinedepaula@unb.br

[1]Universidade Federal do Rio de Janeiro, COPPE - Departament of Mechanical Engineering, Center for Nonlinear Mechanics, 21.945.972 - Rio de Janeiro - RJ, Brazil, savi@mecanica.ufrj.br

Keywords: Piezoelectric materials, energy harvesting, chaos control, sensors, actuators.

Piezoelectric materials consist in a class of smart materials with an electromechanical coupling, presenting two main effects: direct and inverse. In the direct effect, where a mechanical strain leads to a distribution of electrical charges on the surface of the material, these materials can be explored as sensors. In the inverse effect, that occurs when the material is subjected to external electric fields causing changes in shape and size, these materials is usually explored as actuators.

This work exploits the idea of the use of piezoelectric materials as sensors and actuators in energy harvesting systems. The main objective of these systems is the vibration-based energy harvesting where available mechanical energy is converted into electrical energy. In this regard, piezoelectric materials are employed to establish a mechanical-electrical conversion.

Two piezoelectric structures are analyzed, including numerical and experimental results. Initially, a linear piezoelectric beam subjected to harmonic excitation is experimentally analyzed and used to charge batteries. The harvested energy from harmonically excited systems achieves its best performance when it is excited in its fundamental resonance. If the excitation frequency is changed slightly, the power output is drastically reduced. Thus, there are research efforts focused on the concept of broadband energy harvesting to overcome this drawback. An interesting alternative is to explore nonlinear bistable energy converters. The search for broadband energy harvesters includes harmonic and randomly excited system. In this regard, a bistable nonlinear piezomagnetoelastic structure subjected to random vibrations is investigated and a condition for energy harvesting enhancement is established. Afterward, the same piezomagnetoelastic structure is analyzed under harmonic and random excitations. The goal is to present an investigation of the best electrical output response of the system. It is proposed a methodology to evaluate the system performance when both harmonic and random excitations are considered together.

Finally, the use of piezoelectric materials as actuators is incorporated in the system considering the bistable piezomagnetoelastic structure subjected to harmonic excitation. The actuator is considered for control purposes, exploiting chaos control techniques with two different goals: vibration reduction, where vibration amplitudes should be reduced; and energy harvesting, where large amplitude responses are exploited to generate energy. In both situations, chaos control is simultaneously employed with vibration energy harvesting. Both control actuation and energy harvesting are induced employing piezoelectric materials. In the case of vibration reduction, the goal is that the controller can use the harvested energy. In the case of energy harvesting, the control is used to obtain a better performance of the device. Results show that controller power supply is provided partially or fully by the power harvester, depending on the chaos control technique employed.