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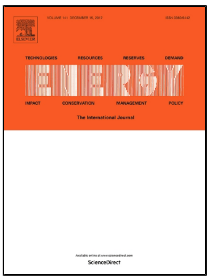

A Dimensionally Reduced Order Piezoelectric Energy Harvester Model

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A Dimensionally Reduced Order Piezoelectric Energy Harvester Model

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Abstract: Presently reduced power requirement for small electronic components have been the main motivation for developing vibration based energy harvesting. The ultimate objective in this research field is to provide an easy, sustainable and efficient technology to power such small electronic devices from the unused vibrational energy available in the environment. A comprehensive, reliable mathematical technique is thus in high demand which can model a piezoelectric energy harvester, predict its coupled dynamics (structural and electromechanical) accurately. The present work focuses on developing a mathematical model for a slender, piezoelectric energy harvester based on Variational Asymptotic Method, a dimensional reduction methodology. Variational Asymptotic Method approximates the 3D electromechanical enthalpy as an asymptotic series to formulate an equivalent 1D electromechanical enthalpy functional to perform a systematic dimensional reduction. For validation purpose, we have picked up experimental results for a bimorph PZT harvester, available in the literature. We have studied the extension-bending structural coupling along with the parameter dependence of the voltage, power output from the harvester and validated with the experiments. The present study provides an unique, accurate modelling technique which is capable of capturing material anisotropy, structural coupling and can analyse arbitrary cross section, surface mounted as well as embedded piezo layered energy harvester.

Keywords: Variational Asymptotic Method, asymptotically correct model, energy harvester, piezoelectric material, base excitation.

1. Introduction

In last few years there has been a surge of research in vibration based energy harvesting. The process of acquiring the unutilized energy from the surrounding and converting it into some usable form of energy is termed as energy harvesting. With the emerging miniature sized electronics and its various applicability in different domain, the need to power such devices with optimal maintenance has also increased [1]. Electromagnetic, electrostatic and piezoelectric are the three very basic energy conversion technique as stated in a very initial article by William and Yates [2]. It has also been mentioned that the significant advantage of piezoelectric material in energy harvesting as compared to the other two basic energy conversion mechanism i.e electromagnetic and electrostatic are its large power density and ease of application. A review article highlighting the advancement of power harvesting from piezoelectric materials was published by Anton and Sodano [3]. Also an article was published reviewing different strategies for increasing the operating frequency range of vibrating energy harvester [4]. The major