Design, Development and Optimization of the Axial Piezoelectric Energy Generator

Rakesh Kumar Haldkar

Laboratory of Mechanics and Physics of New Materials and Devices

rakeshhaldkar@gmail.com

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Abstract

The design and development of an axial type piezoelectric generator is presented. A computational and experimental approach to modeling oscillations of a new axial-type piezoelectric generator (PEG) with an attached mass is considered. In d_{31} mode, a force is applied in the perpendicular direction and in d_{33} mode, a force is applied in the direction of polarization. Therefore, the piezoelectric energy generator can be divided into two types: cantilever (d_{31}) and axial (d_{33}) mode. The cantilever-type piezoelectric power generator has been found to be more suitable for small forces and low vibration levels; at the same time, the axial type is suitable for high force excitations. This design is a combination of the above loading conditions. The axial type piezoelectric energy generator is designed in such a way that, (a) an L-shaped beam compresses-tenses the piezoelectric cylinder, (b) the duralumin base plate deforms the piezoelectric bimorph, and (c) various proof mass can be adjected in the duralumin-based plate for obtainment of various eigen values as shown in Figure 1. Due to the above flexibilities, the energy harvester design is compatible with various mechanical vibrations inputs.

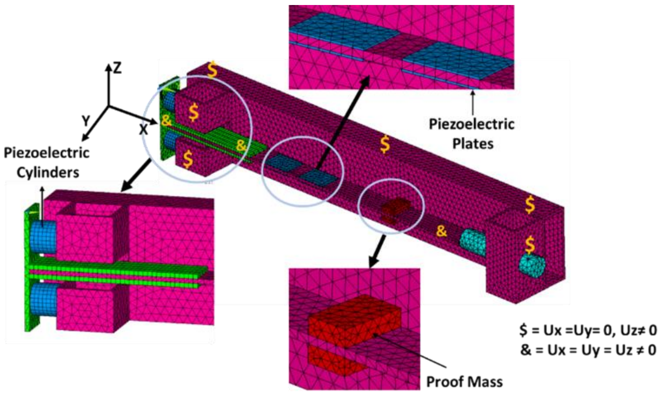

Figure 1. Axial type piezoelectric generator

The analysis of the above design is considered into two domains active and passive. The first study is focused on the optimization process in the passive domain, that increases the output voltage for given mechanical excitation. The task is to optimize the design in such a way as to obtain the optimal output voltage for a given mechanical excitation. The optimization process is divided into several steps, which significantly reduces the number of calculations. In the optimization, the process can be developed for specific operating conditions, various lengths of duralumin base plate, the various position of proof mass, and different applied acceleration. It has been modeled and analyzed for axial-based piezoelectric generators. The maximum voltage and power are observed 11.64 V and 1355 μw at 633 Hz, respectively, when the length of the duralumin base plate is 150 mm and 5 m s^{-2} acceleration. The second study is focused on the various porosities of piezoelectric ceramics has been analysed. The porosity of piezoelectric ceramic varies from 0 to 80% through the thickness or along the length of the duralumin beam.

Publication List:

1. Cherpakov, A.V.; Parinov, I.A.; Haldkar, R.K. “Parametric and Experimental Modeling of Axial-Type Piezoelectric Energy Generator with Active Base”. *Appl. Sci.* **2022**, *12*, 1700.

2. Haldkar R. K., Cherpakov, A.V.; Parinov, I.A. Modeling, analysis and design optimizations of an axial-type piezoelectric energy generator for optimal output” 2022 Smart Mater. Struct. 31 065019

3. Haldkar R. K., Cherpakov, A.V., Parinov, I.A., Yakovlev V. E., “Comprehensive numerical analysis of a porous piezoelectric ceramic for axial load energy harvesting” Applied Sciences, 2022. (Minor Revision).