INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

The objective of the presented work is to improve the electrical power output by modifying the geometry of the piezoelectric vibration energy harvester (PVEH). The key contributions of the thesis are, modification of the thickness profile of conventional cantilever-based bimorph PVEH to achieve uniform stress along the beam length. In this regard, two thickness-tapered geometries are proposed: PVEH-1, which consists of a thickness-tapered substrate sandwiched between two uniform thickness piezoelectric layers, and PVEH-2, which consists of a bimorph cantilever with a substrate of uniform thickness sandwiched between two thickness-tapered piezoelectric layers. In diaphragm-based PVEH, radial cuts are introduced to reshape it in identical slices (sectors) of 32.7° each resulting in improved harvested power. Further, a broadband energy harvester is designed using several slices of different central angles.

Analytical expressions are derived for both the proposed devices PVEH-1 and PVEH-2, and solved for sinusoidal input excitations to evaluate cantilever end-mass displacement, stress on the beam and generated voltage across load resistance. The results from the analytical expressions are validated with that of the finite element (FE) analysis of an identical PVEH for both the proposed devices. The performance of PVEH-1 and PVEH-2 are compared with the performance of corresponding equivalent conventional PVEH of uniform thickness. The comparison result shows that both the proposed devices show uniform stress distribution along the beam length and generate more electrical power compared to conventional PVEH of uniform thickness. The peak stress on both the proposed PVEH devices is less than the corresponding conventional devices. Because of the reduced peak stress, both the proposed PVEHs are suitable for harvesting energy from vibration sources of high accelerations and, at the same time are more reliable in terms of mechanical failure.

Another popular geometry investigated in the thesis is diaphragm-based PVEH. The diaphragm-based PVEH generally has a high resonance frequency of vibration, and the stress distribution is mainly concentrated at the central portion. A diaphragm-based PVEH is modified by dividing into several identical sectors to reduce the resonance frequency and improve the stress distribution. It is observed that the slicing of the diaphragm reduces the resonance frequency of vibration and increases the harvested power. The optimal slicing angle for the best performance is found from the FE analysis results. It is also observed that the slices of different angles exhibit different resonance frequencies. A set of different angular slices are combined to design a broadband energy harvester.