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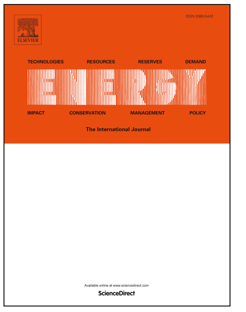

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Optimized Design of Layered Bridge Transducer for Piezoelectric Energy Harvesting from Roadway

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ABSTRACT: This study aims to develop a novel design of piezoelectric transducer with the optimized geometry that is targeted for energy harvesting in roadway under vehicular loading. The Bridge transducer with layered poling and electrode design is proposed to enhance energy output. Finite element analysis (FEA) was conducted to predict energy output and stress concentration in the transducer. Multi-physics simulations were conducted to evaluate energy outputs using different lead zirconate titanate (PZT) materials, loading magnitudes, transducer types, and geometry parameters. The optimum configuration of transducer geometry was evaluated considering the balance between energy harvesting performance and mechanical failure potential due to stress concentrations. The novel design of Bridge transducer with layered poling and electrodes produces much greater energy than the traditional bridge and Cymbal transducer. The results show that within the failure stress criteria, the optimized design of Bridge transducer produced an electrical potential of 556V, which could result in 0.743mJ of potential energy (open circuit condition) for a single transducer under the external stress of 0.7MPa. Laboratory testing on energy harvester module showed that simulation results agreed well with the measured power.

KEYWORDS: Bridge Transducer; Piezoelectric Energy Harvesting; Finite Element Analysis; Geometry Optimization

NOMENCLATURE

A	Surface area of PZTceramic element (m^2)
C	Capacitance of the material (Farads)
D	Electric displacement tensor (charge/area)
d_{ij}	Piezoelectric charge constant (pC/N)
E	Electric field (V/m)
g_{3i}	Piezoelectric voltage constant of PZT (10^{-3} V m/N)
k	Electromechanical coupling factor
L_c	Total width and length of Piezoceramic (mm)
L_i	Inner length of the end cap (mm)
L_o	Length of the cavity base (mm)
n	number of segments between electrodes
P_3	Piezoelectric polarization at the 3rd axial direction
S	Strain tensor
S^E_{ij}	Elastic Compliance tensor at the constant E condition (10^{-12} m^2/N)
T, T_i	Stress tensor (MPa)