Electromechanical-Traffic Model of Compression-Based Piezoelectric Energy Harvesting System

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Abstract : Piezoelectric energy harvesting has advantages over other alternative sources due to its large power density, ease of applications, and capability to be fabricated at different scales: macro, micro, and nano. This paper presents an electromechanical-traffic model for roadway compression-based piezoelectric energy harvesting system. A two-degree-of-freedom (2-DOF) electromechanical model has been developed for the piezoelectric energy harvesting unit to define its performance in power generation under a number of external excitations on road surface. Lead Zirconate Titanate (PZT-5H) is selected as the piezoelectric material to be used in this paper due to its high Piezoelectric Charge Constant (d) and Piezoelectric Voltage Constant (g) values. The main source of vibration energy that has been considered in this paper is the moving vehicle on the road. The effect of various frequencies on possible generated power caused by different vibration characteristics of moving vehicle has been studied. A single unit of circle-shape Piezoelectric Cymbal Transducer (PCT) with diameter of 32 mm and thickness of 0.3 mm be able to generate about 0.8 mW and 3 mW of electric power under 4 Hz and 20 Hz of excitation, respectively. The estimated power to be generated for multiple arrays of PCT is approximately 150 kW/ km. Thus, the developed electromechanical-traffic model has enormous potential to be used in estimating the macro scale of roadway power generation system.

Keywords : piezoelectric energy harvesting, cymbal transducer, PZT (lead zirconate titanate), 2-DOF