Power Generation Improvement for Piezoelectric Energy Harvesting for Roadsides Sustainability

[1]Mohammad Ahad, [2]Seonghoon Kim, [2]Junan Shen,
[1]Dylan rice
[1]Dept of Electrical Engg and [2]Dept. of Civil Engg and Construction Management
Georgia Southern University, Statesboro, USA

Ilan Stern
Georgia Tech Research Institute (GTRI)
ATAS Energy and Sustainability Lab
Atlanta, GA

Abstract— **Piezoelectric (PZT) based energy harvesting is an exciting way of renewable power generation. Their use of energy harvesting in highways is a great possibilities for next generation power harvesting. In this study, power generation capabilities of these PZTs were compared when they are embedded in nine different materials while these will be used for power generation in roadsides or walkways. Power generation improvement also analyzed for these materials for both direct and indirect application of force to these materials. It is found that PZT produces most power while embedded under foam while direct force is applied and aluminum produces most power when force is applied indirectly.**

Keywords—PZT material, Energy harvesting, Power

I. INTRODUCTION

Piezoelectric materials can be used to convert oscillatory mechanical energy into electrical energy. Piezoelectric (PZT) energy harvesting technology has significant advantages over other renewable energy sources such as solar, wind, and geothermal [1, 2]. Using the gravitational force of running vehicles, power can be produced on the roadways when piezoelectric materials are embedded into the asphalt highways [3]. This technology has been tested for a variety of purposes, including sensors [4], for roadway lighting and bridge bearing, structural health monitoring [2, 3], deicing and traffic monitoring. Although recent research projects have paid attention to this energy harvesting technology, few data are available for its use under or in roadway pavements. The materials include, but are not limited to, carpets, rubber, concrete, asphalt, etc. There is a highly urgent need to develop a lab-scale research framework that enables assessment of the technology on the PZ material and other materials coupled with it.

II. METHODS

An Asphalt Pavement Analyzer (APA) is used to test PZT materials embedded in different kind of materials. The APA can be set to run in different speed. This experiment was conducted under the assumption of 600 vehicles per hour at 45 mph. The load on the asphalt mix from each vehicle was 100 lbs. In this study, APA frequency was set to 30 Hz. Nine different kind of materials are used in this project to test their abilities to generate power when two PZTs were embedded into each of those materials. One PZT was under direct force and the other was under indirect force which means this PZT is not directly under the APA load but gets the force when the APA loader runs through the material. Measurement of voltage generated was measured at no load and with load condition. For loading condition, the PZTs were directly connected to a bridge rectifier and the generated output voltage was measured across a resistor. A potentiometer was used to change the load resistor value. Diodes used for bridge rectifier were 1N4001 and an electrolyte capacitor of 10 µF was used across output resistor. An oscilloscope was also attached to the load to see the voltage wave shapes.

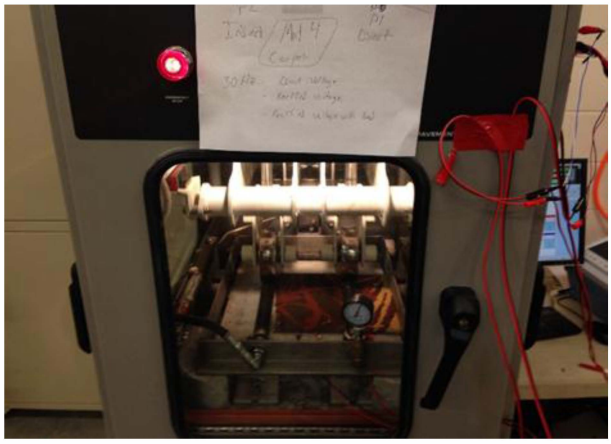

Fig 1: APA machine

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Table 1: Power in PZT coupled with different materials.

	Black Metal Board	Multi Purpose Aluminum	Poly-Carbonate	Carpet Tile	Foam	Astro-Turf	Classic PUTT	Syn-Play-C60	Green Astro-Turf
Power (direct) Watt	1.1E-6	4.21E-11	1.03E-6	9.23E-7	8.08E-6	1.35E-6	1.33E-6	2.38E-6	1.08E-6
Power Indirect Watt	1.19E-6	2.96E-6	6.18E-7	1.23E-8	6.1E-10	4.7E-11	4.7E-11	2.23E-8	6.35E-8

III. RESULTS

Table 1 shows the experimental results collected from nine different materials. The resistor value around 1MΩ provided optimal power generated from most of the materials. Table shows that, PZT under foam with direct force produces the most power and Aluminum produces the most power while under indirect force on the APA machine.

Fig 2: PZTs (one gets direct force other indirect)

IV. DISCUSSIOIN

Evaluating power measurement capability of PZT under different materials under or in the pavement materials, tiles or carpet is important for energy harvesting. It is also important to understand the economics of PZT and the variance in the PZT units. The scope of this experiment will be much larger scale lab experiments with immense numbers of data and variables. This study will provide a detail description of how much voltage and power each material can produce. Future studies on these materials will also reveal the strength and durability of these materials, factors that can affect the strength and durability of these materials.

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