Application of Piezoelectric Material in Roads To Harvest Energy

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Abstract

In this century, harvesting energy has become a hopeful solution to worldwide energy issues. In addition, harvesting energy is possible without the use of existing natural resources which allow no harm to the planet. Energy harvesting technologies from roadways has been pinned pointed as a new ground breaking research area where wasted energy is kept captive as a result of human or vehicle interaction with roads. This energy it is then concentrate, and saved for future use. This method of energy harvesting is possible due to vibration. The following paper inclines to the production of energy using the approach of piezoelectric effect by means of PZT or lead zirconate titanate, as roads today have become ground zero for production of pollution free electricity.

Methodology

To begin this research project a small size piezoelectric material was tested using a shaker apparatus to simulate a vertical movement. This movement was controlled by the frequency signal manipulated by the Waveform Generator and amplified if needed by the Power Amplifier. Using LabView, a laboratory instrument workbench which allowed to detect the highest natural frequency by identifying the highest point of strain of the material and therefore agreeing with the most natural frequency this material would attain of 172 Hz with a resistance of 1K ohms. It was then that by using Ohm's Law, a final amount of effective power of 0.6 mW. The following are the properties of the piezoelectric cantilever material Ttable 1):

Table 1: The properties of the piezoelectric cantilever material

Property	Symbol	Value
Length (mm)	L	35
Width (mm)	b	10
Structure thickness (mm)	t_s	0.1
Structure density (kg/m^3)	ρ_s	8960
PZT thickness (mm)	t_p	0.2
PZT density (kg/m^3)	ρ_p	7800
PZT modulus (GPa)	c_p	72
PZT dielectric constant	K_3^T	3500
PZT strain constant (m/V^1)	d_{31}	-270×10^{-12}

Using this material helped become familiar with the material before moving on to the next phase of the research project which was a field test using a real size vehicle.

For the next phase, the type of research that was used in this study was sampling different boundary conditions when testing the Piezo Film Sheet in order to attain the most efficient voltage output out of all of them

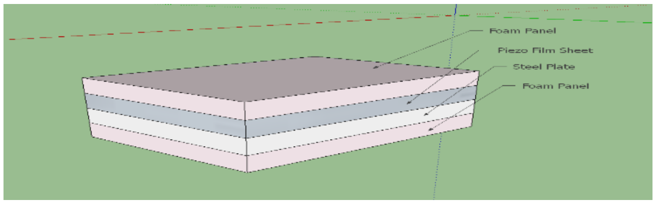

Figure 1

The first boundary tested **(Figure 1)**, was a cantilever orientation. This involved attaching a Piezo film Sheet to a metal surface that will allow the piezo film sheet vibrate once a force acted on it. A foam panel was placed on each side to protect the film. The Piezo film sheet contains a silver ink that contributes with the process of polarization which is how the charge is produced and requires to be protected. Red and black wires were attached to the positive and negative side of the film sheet. The sheets were tested before assembly connecting it to an oscilloscope which read the voltage produced by pressure acting on the material. For this orientation one side of the sheet was clamped simulating on sided fixed.

Figure 2

The second boundary condition **(Figure 2)** was a simply supported orientation, To achieve this both sides were left free to rotate and have no moment resistance.

Figure 3

The third boundary condition **(Figure 3)**, was a film sheet fixed at both ends using clamps on both ends, restrained from rotation.

Figure 4

The fourth boundary condition **(Figure 4)**, was leaving the film sheet flat no boundary condition using self-weight. All these conditions were tested and the results for each case was a peak voltage of 5.08V which 3.59V is effective.

Figure 5

Depending on the resistance used, the max effective power output would be 12.89 watts. For simplicity the fourth boundary condition was used knowing all conditions supply the same amount of output.

Conclusion

At the end of this research project it is concluded that energy can be harvest using Piezo film sheets. Existing projects in the state of California and in Israel are living proof of the progress this technology has. Arizona State University is a proud example of energy harvesting by deploying the largest university solar installation. Their solar panels meet up to 7 percent of the energy needs for ASU's Tempe campus. Such way to harvest energy give young projects like this one hope to improve and potentially place University of New Haven as a high energy harvesting school in the United States.

For the future, it is expected to apply new boundary conditions for the Piezo film sheets in order to allow it more freedom without constraining it with the foam panel. Also, simulate a real street scenario using materials such as asphalt. In this case temperature plays a big role since asphalt reaches temperatures of 200 degrees Fahrenheit and the film sheets can only be subjected to possibly 150 degrees Fahrenheit.

Biography

My name is Gregory Aliaga, my nationality is Peruvian. I'm a current undergraduate Civil Engineering and Applied mathematics major. I currently have an internship at Walsh working on the Q-Bridge. On my free time I like to spend time with my nephews Idris and Kevin. We enjoy playing video games and movies.