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SUCESSOR OF TODAY'S ELECTRICITY HOUSE

PIEZOELECTRIC MATERIAL

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I.INTRODUCTION

India is the world's third largest producer and fourth largest consumer of electricity. During the fiscal year 2016-17, the gross electricity generated by utilities in India was 1,236.39 TWh and the total electricity generation (utilities and non utilities) in the country was 1,433.4 TWh. The gross electricity consumption was 1,122 kWh per capita in the year 2016-17.

The generation of this electricity cost very high and a lot of the total income is spend on the electricity generation. In order to minimize this cost there are certain alternative methods to generate electricity.

II.HEADING

Piezoelectricity is an alternative way to generate, store and use electricity.

1.1 What is piezoelectricity ?

1.2 Piezoelectricity is the electric charge that accumulates in certain solids materials (such as crystals, certain ceramics, and biological matter such as bone, DNA and various proteins)[1] in response to applied mechanical stress. This applied mechanical stress leads to the formation of the positive and negative charges on the opposite faces of the crystal.

The development of the charges is due to the non-centro-symmetric arrangement of the atoms in the crystal structure. This type of arrangement does not allow the center of gravity of positive and negative charges to coincide with each other and this leads to the formation of dipole. These dipole moments get arranged in random directions when the crystal is in its original state and hence the net dipole moment is zero. As the mechanical stress is applied these dipole moments get arranged in single direction and hence potential difference is created.

Some of the piezoelectric materials are :

Naturally occurring crystals

1. Quartz
2. Berlinite ($AlPO_4$), a rare phosphatemineral that is structurally identical to quartz
3. Sucrose (table sugar)
4. Rochelle salt
5. Topaz
6. Tourmaline-group minerals
7. Lead titanate ($PbTiO_3$).

Synthetically obtained

1. Langasite($La_3Ga_5SiO_{14}$), a quartz-analogous crystal
2. Gallium orthophosphate ($GaPO_4$), a quartz-analogous crystal
3. Lithium niobate ($LiNbO_3$)
4. Lithium tantalate ($LiTaO_3$)
5. Barium titanate ($BaTiO_3$)—Barium titanate was the first piezoelectric ceramic discovered.
6. Lead zirconatetitanate ($Pb[Zr_xTi_{1-x}]O_3$ with $0 \leq x \leq 1$)—more commonly known as PZT, lead zirconate titanate is the most common piezoelectric ceramic in use today.
7. Potassium niobate ($KNbO_3$)
8. Sodium tungstate (Na_2WO_3)
9. $Ba_2NaNb_5O_5$
10. $Pb_2KNb_5O_{15}$
11. Zinc oxide (ZnO)–Wurtzite structure.

III.EXPERIMENTAL RESULTS AND DISCUSSIONS:

Parametric Optimization-

The voltage outputs from the piezo-film can be varied depending to on the piezo-beam configuration as well as the force location on the beam. Therefore, the piezo-beam-force configuration has to be optimized in order to gain the maximum output from the power generator. A series of investigation were carried out to determine optimum parameter of the experimental setup given in Figure 2.

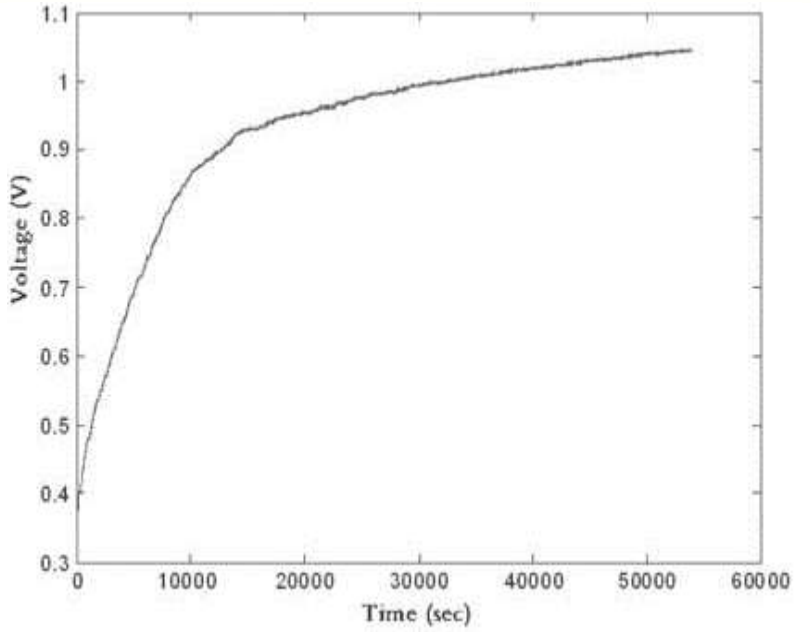
The PZTlocationwas found to be the bestwhen itwas attached next to clamped end of the beam (refer to Figure 2). The PZT length was optimized at a ratio of 0.54 to the beam's length

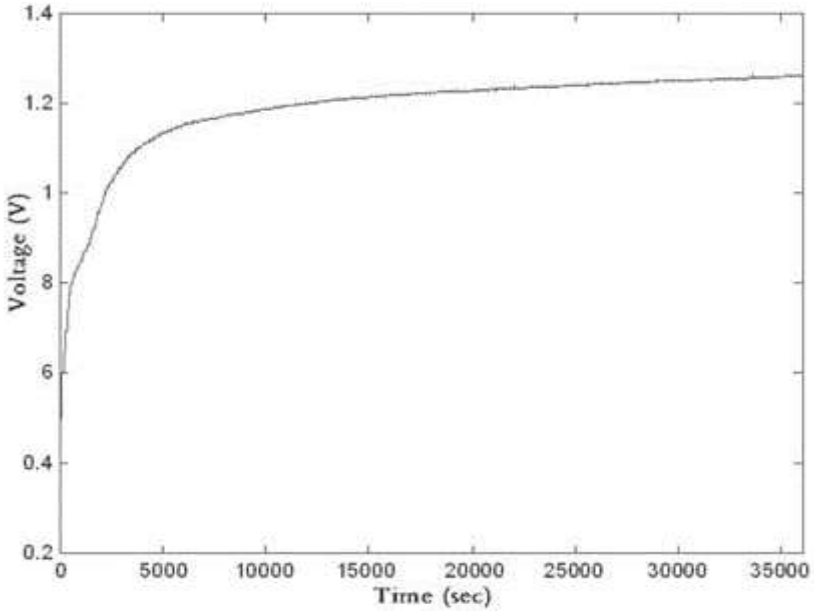
whereas the thickness is optimized at the ratio of 0.53. The forcing function's optimal positionwas the farthest point from a clamped end as thiswould cause the largest moment on the beam, and the voltage outputs is proportional to the applied moment. By using these optimized variables, the power produced using the Euler Bernoulli method is increased over 150 times for the harmonically driven case and 12 times for the randomnoise driven case

Harvesting Electrical Energy From the Piezo-film-

The investigation shows that the power output from a single piezo-film was very low in the range of 0.2 W. Therefore, direct application of the piezo-film as a power source is not practical. It is unavoidable to use a storage device to collect theweak power output for future usage. Fortunately, the voltage outputs from a single piezo-film can produce a root-mean-squared voltage of 1.18 V which is high enough to store the generated electricity into a small nickel metal hydride battery. Figure 4 shows the charging time of a 1.2V-2500 mAh nickel metal hydride battery at random force and at resonance frequency, respectively. This is equivalent to 14 hours of charging time using random force and 10 hours at resonance frequency.

After the rechargeable battery had been fully charged up, it was discharged through a load of 10 k for 1 hour. During this discharging period, the current measured remained steadily at 760 mAand the potential difference across the resistor was 1.2 V. This is equivalent to an estimated power of about 0.9W





IV.APPLICATIONS

1. Piezoelectric material can be used in the car tyre which can generate AC current and this current can be converted to DC current and stored in the car battery i.e. the car battery can be charged or an alternate battery can be used to store the charge. e.g. lithium ion battery

2. Piezoelectric material can be used inside the roads especially highways. For 1km of the piezoelectric road of a single lane we can generate 44000kW-hr/yr. India has 228 highways which has a total length of 70,548km.If piezoelectric material is used in these highways it can generate 3104 GW-hr/Yr.

3. Piezoelectric material can be used in the mobile screen and the mobile battery can be charged using the piezoelectric effect.

4. Piezoelectric materials are also in use in the shoes and the electricity generated can be stored in the lithium ion battery.

NOTE: In all the above applications the generated electricity will be not as desired and hence an amplifier should be used to get the desired output. Also the piezoelectric material used commonly is quartz.

V.CONCLUSION

The ideas mentioned above has many advantages and some disadvantages also.

ADVANTAGES-

1. Cost reduction in generation of electricity. The material used (quartz) will has a life period of 30 years and the amount spent for the road project will be returned in just 4-5 years span and the remaining 25-26 years will give the desired profit.
2. Electricity will be available for the consumers at a cheaper rate.
3. The dependency of India for the raw material for electricity generation will also reduce.
4. The villages which do not receive electricity will be supplied with sufficient amount of electricity.
5. The project will lead to eco-friendly generation of electricity.
6. No need of frequent maintenance.

DISADVANTAGES-

1. Maintenance of the project is bit difficult.
2. High temperature may lead to damages.
3. Overstress can lead to cracks in the crystals.

It can also be used in :

1. Paddle of cycle
2. Paddle of acceleration and brake
3. Above and below of shock absorbers
4. Cricket and football ground or running track
5. Footpath

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