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Energy Harvesting From Vibration Based Impact Modes

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Abstract:-Man has needed and used energy at an increasing rate for the sustenance and well-being since time immemorial. Due to this a lot of energy resources have been exhausted and wasted. Proposal for the utilization of waste energy of foot power with human locomotion is very much relevant and important for highly populated countries like India where the railway station, temples etc., are overcrowded all round the clock .When the flooring is engineered with piezoelectric technology, the electrical energy produced by the pressure is captured by floor sensors and converted to an electrical charge by piezo transducers, then stored and used as a power source. And this power source has many applications as in agriculture, home application and street lighting and as energy source for sensors in remote locations

Keywords:-Piezoelectricity, PZT, PVDF, Inverter,

1. INTRODUCTION

At present, electricity has become a lifeline for human population. Its demand is increasing day by day. Modern technology needs a huge amount of electrical power for its various operations. Electricity production is the single largest source of pollution in the whole world. At one hand, rising concern about the gap between demand and supply of electricity for the masses has highlighted the exploration of alternate sources of energy and its sustainable use. On the other hand, human population all over the world and hence energy demand is increasing day by day linearly. Accordingly, it is an objective of the present invention to provide a method of electrical power generation from this ever increasing human population that does not negatively impact the environment. This technology is based on a principle called the piezoelectric effect, in which certain materials have the ability to build up an electrical charge from having pressure and strain applied to them. Piezoelectricity refers to the ability of some materials to generate an electric potential in response to applied pressure. Harvesting of energy which means energy is already available, but is going to waste if not utilized. Embedded piezoelectric material can provide the magic of converting pressure exerted by the moving people into electric current.

In the recent smart world Electricity is **an essential part of modern life and important to the U.S. economy**. People use electricity for lighting, heating, cooling, and refrigeration and for operating appliances, computers, electronics, machinery, and public transportation systems. In general, environmental energy exists in various forms, such as light, heat, electromagnetic fields, and mechanical vibrations. Harvesting energy from mechanical vibrations is more attractive, partially because mechanical vibrations are ubiquitous and independent of the season, weather and locations. Vibrational harvesters have relatively high energy density (about 0.3 $\mu W/mm^3$) and the availability of

low-power circuits and sensors (μW –mW range) makes vibrational energy harvesting a suitable energy source for various application scenarios.

In this paper, we present a vibration energy harvester based on the indirect impact of spring less spherical proof mass to harvest energy from low-frequency vibrations such as human-body-induced motion while overcoming the issues of conventional devices using direct impact. To avoid the physical contact of the piezoelectric material and to improve reliability, the kinetic energy of the spring less proof mass is conveyed to the piezoelectric cantilever via metal housing during impact. In contrast to the conventional piezoelectric vibration generators where input acceleration has to be applied vertically to the piezoelectric cantilever, external vibration is applied in the length direction of piezoelectric MFC (Macro Fiber Composite) beam, which significantly reduces the device volume.

In addition to the improvement of long-term reliability by protecting the piezoelectric cantilever from making contact with any of the structural materials, proposed design can benefit from an increase of acceleration during the reciprocating motion of the proof mass inside the channel. The proof mass collides with the end wall of the channel at an acceleration higher than that of the external vibration of sinusoidal nature. Also, the fixed end of the MFC has been designed to efficiently deliver the vibration of the housing induced by much larger spring less proof mass to the MFC cantilever, which maximizes the output power. Thorough investigation of the operating mechanism has been carried out by comparison between the experimental results and analytical model. A finite element analysis (FEA) has also been performed to confirm the resonance mode of the proposed device. In this paper we discuss three modes of generation rain drop, foot step, triboelectricity.

1.1 Rain Drop:

Raindrop electricity generation has previously been employed as a form of microgeneration to power houses and small water purification systems – by capturing and funnelling rainwater to drive small turbines. Another method used piezoelectric materials that generate electricity based on energy released when raindrops hit a surface.

1.2 Foot step:

we propose an advanced footstep power generator system that uses peizo sensors to generate power from human footsteps. The system allows for a platform for placing footsteps. The peizo sensors are mounted below the platform to generate voltage from footsteps.The sensors are placed in such an arrangement so as to generate maximum output voltage. This is then provided to our monitoring circuitry. The circuit is a microcontroller based monitoring circuit that allows user to monitor the voltage and charges a connected battery by it.It also displays the charge generated and displays on an LCD display.

1.3 Triboelectriciy :

Triboelectric effect is a known phenomenon for a long time, and in this effect, charges are generated when two surfaces are in friction. The triboelectric effect is now considered to be related to the phenomenon of adhesion, where two materials composed of different molecules tend to stick together because of attraction between the different molecul While adhesion is not a chemical bond between atoms, there is an exchange of electrons between the different types of molecules, resulting in an electrostatic attraction between the molecules that holds them together. Physical separation of materials that are adhered together results in friction between the materials. Because the electron transfer between molecules in the different materials is not immediately reversible, the excess electrons in one type of molecule remain left behind, while a deficit of electrons occurs in the other.

1.4 Electricity generation due to raindrop:-

Raindrop electricity generation has previously been employed as a form of microgeneration to power houses and small water purification systems – by capturing and funnelling rainwater to drive small turbines. We are now generating electricity by Another method used piezoelectric materials that generate electricity based on energy released when raindrops hit a surface.Kinetic energy from falling raindrops is effectively turned into electrical energy. Surface charge accumulates on the device as the drops hit and is then discharged as spreading water connects the two electrodes. Power density and energy conversion efficiency achieved by this system is thousands of times greater than similar devices.Materials used in this new droplet-based electricity generator combine a polytetrafluoroethylene film with an indium tin oxide electrode and aluminium electrode.

1.5 Piezoelectric method:-

Piezo is Greek for "to squeeze or press". Hence, piezoelectric materials are those that generate an electrical voltage (or electricity) in response to applied mechanical stress. Materials demonstrating a piezoelectric effect also demonstrate the opposite effect called the converse piezoelectric effect. This means that upon the application of an electric charge, they become deformed. These materials can be crystalline, ceramic even biological matter, such as bones and proteins.

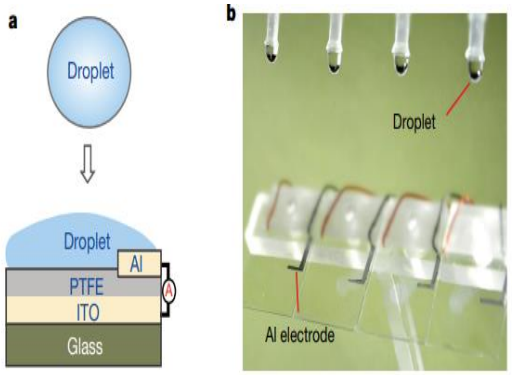


Figure 1 power generated

The power generated by the vibration of the piezoelectric is shown to be a maximum of 2mW, and provide enough energy to charge a 40mAh button cell battery in one hour. piezoelectric materials form transducers that are able to interchange electrical energy and mechanical motion or force.According to the analysis performed by the authors, the mechanical to electrical power conversion efficiency 18 of such piezoelectric generator can reach 37% Piezoelectric materials are capable of transforming mechanical strain and vibration energy into electrical energy

1.6 Fabrication of the Device. :-

One surface of the PTFE film (25 mm × 75 mm × 0.03 mm) was deposited with a gold electrode by sputter coating. Then a 15 mm × 2 mm copper tape was pasted onto the other surface as the top electrode. Finally, the film was supported onto a glass slide.

1.7 Electricity generation due to foot-step:-

way to generate electricity by using a population of humans had been discovered When walking, the vibration that generates between the surface and the footstep is wasted. By utilizing this wasted energy, the electrical energy can be generated and fulfill the demand. The transducer that use to detect the vibration is a piezoelectric transducer. This transducer converts the mechanical energy into electrical energy.

2. PURPOSED METHODOLOGY

The piezoelectric material converts the pressure applied to it into electrical energy. The source of pressure can be either from the weight of the moving vehicles or from the weight of the people walking over it. The output of the piezoelectric material is not a steady one. So a bridge circuit is used to convert this variable voltage into a linear one. Again an AC ripple filter is used to filter out any further fluctuations in the output. The output dc voltage is then stored in a rechargeable battery. As the power output from a single piezo-film was extremely low, a combination of few Piezo films was investigated. Two possible connections were tested - parallel and series connections. The parallel connection did not show a significant increase in the voltage output. With series connection, additional piezo-film results in an increase of voltage output but not in linear proportion. So here a combination of both parallel and series connection is employed for producing 40V voltage output with high current density. From, battery provisions are provided to connect dc load. An inverter is connected to the battery to provide provision to connect AC load. The voltage produced across the tile can be seen in a LCD. For this purpose microcontroller PIC16F873A is used. The microcontroller uses a crystal oscillator for its operation. The output of the microcontroller is then given to the LCD which then displays the voltage levels.

2.1 Commercial Utility:

1] Along the central crossing between London's Olympic stadium and the recently opened Westfield Stratford City mall 20 tiles will be scattered withan estimated footfall of 30 million people in the first year.

2] In front of ticket counters and every time a passenger steps on the mats, special flooring tiles were installed and they trigger a small vibration that can be stored as energy.

3] We can implement this system in the floor area of stairs, schools and colleges where thousands of students are studying.

2.2 Electricity generation due to foot-step & raindrop:-

At present, electricity has become a lifeline for the human population. Its demand is increasing day by day. Modern technology needs a huge amount of electrical power for its various operations. Electricity production

is the single largest source of pollution in the whole world. At one hand, rising

concern about the gap between demand and supply of electricity for masses has highlighted the exploration of alternate sources of energy and its sustainable use. On the other hand, human population all over the world and hence energy demand is increasing day by day linearly. Accordingly, it is an objective of the present invention to provide a method of electrical power generation from this ever increasing human population that does not negatively impact the environment. This technology is based on a principle called the piezoelectric effect, in which certain materials have the ability to build up an electrical charge from having pressure and strain applied to them. Piezoelectricity refers to the ability of some materials to generate an electric potential in response to applied pressure.Harvesting of energy which means energy is already available, but is going to waste if not utilized. Embedded piezoelectric material can provide the magic of converting pressure exerted by the moving people into electric current

3. HARDWARE IMPLEMENTATION :

The hardware set up is as shown in figure 6. A tile made from piezo material is made. The voltage generated across a piezo tile is supplied to a battery for it to recharge and supply the dc loads. Voltage generated is also given to an inverter, from where it is supplied to all the ac loads. A LCD is interfaced to the tile using a PIC microcontroller to display the voltage generated across the piezo tile.

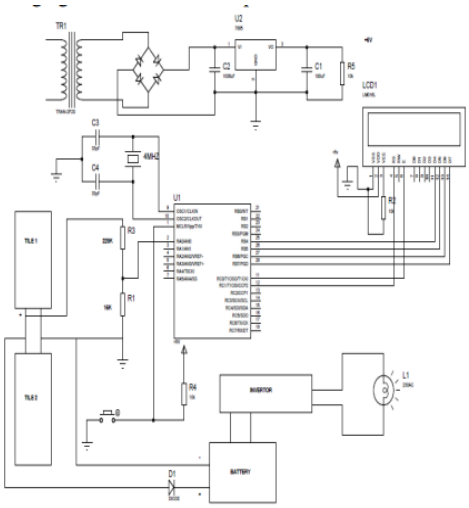


Figure2 Hardware setup

4. WORKING

The piezoelectric material converts the pressure applied to it into electrical energy. The source of pressure can be either from the weight of the moving vehicles or from the weight of the people walking over it. The output of the piezoelectric material is not a steady one. So a bridge circuit is used to convert this variable voltage into a linear one. Again an AC ripple filter is used to filter out any further fluctuations in the output. The output dc voltage is then stored in a rechargeable battery. As the power output from a single piezo-film was extremely low, combination of few Piezo films was investigated. Two possible connections were tested - parallel and series connections. The parallel connection did not show significant increase in the voltage output. With series connection, additional piezo-film results in increased of voltage output but not in linear proportion. So here a combination of both parallel and series connection is employed for producing 40V voltage output with high current density. From battery provisions are provided to connect dc load. An inverter is connected to battery to provide provision to connect AC load. The voltage produced across the tile can be seen in a LCD. For this purpose microcontroller PIC16F873A is used. The microcontroller uses a crystal oscillator for its operation. The output of the microcontroller is then given to the LCD which then displays the voltage levels.

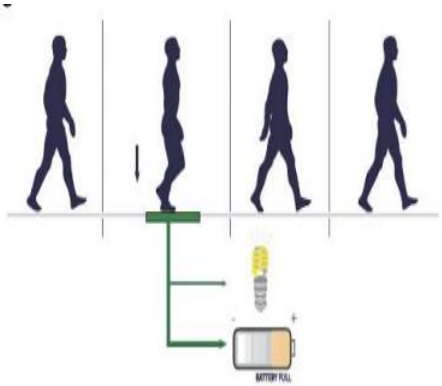


Figure 3 :- Schematic Representation of working model

The inverter used in this circuit uses the IC CD4047. It is used to convert the DC voltage stored in the battery to AC voltage. IC CD4047 produces two pulse trains phase shifted by 180°. These pulse trains are used to switch transistors configured in common emitter mode producing pulse trains of 12V, which is capable of switching a MOSFET. The sources of the two MOSFETs used in the inverter circuit are supplied with a 12V supply. When the MOSFETs are switched on by the outputs of the transistors, two output pulses of 12V are obtained. These pulses are connected to a step up transformer from whose high voltage side; we obtain the 220V AC supply.

5. MAXIMUM THEORETICAL VOLTAGE GENERATED

When a force is applied on piezo material, a charge is generated across it. Thus, it can be assumed to be an ideal capacitor. Thus, all equations governing capacitors can be applied to it. In this project, on one tile, we connect 3 piezo in series.10 such series connections are connected in parallel. Thus when 3 piezoelectric discs are connected in series, its equivalent capacitance

$$\frac{1}{Ceq} = \frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3}$$

$$Q = C * V$$

$$C = \frac{Q}{V}$$

$$\frac{Veq}{Q} = \frac{V1}{Q} + \frac{V2}{Q} + \frac{V3}{Q}$$

Thus, (5) Hence, the net voltage generated in series connection is the sum of individual voltages generated across each piezoelectric disc. Output voltage from 1 piezo disc is 13V. Thus, Veq=V1+V2+V3 (6) = 13+13+13 =39V

5.1 ANALYSIS DONE ON THE PIEZO TILE :

People whose weight varied from 40kg to 75 kg were made to walk on the piezo tile to test the voltage generating capacity of the Piezo tile. The relation between the weight of the person and power generated is plotted in figure 8. From the graph it can be seen that, maximum voltage is generated when maximum weight/force is applied. Thus, maximum voltage of 40V is generated across the tile when a weight of 75 Kg is applied on the tile.

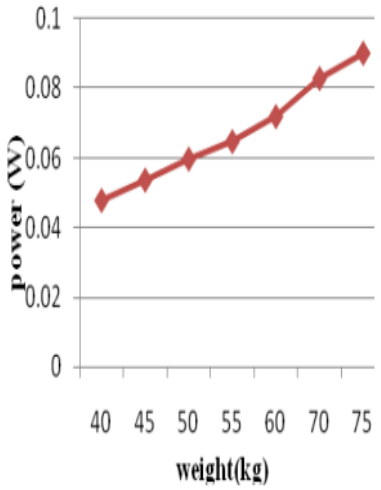


Figure 4 Weight v/s power graph of pizo tile

6. CONCLUSION :

A piezo tile capable of generating 40V has been devised. Comparison between various piezo electric material shows that PZT is superior in characteristics. Also, by comparison it was found that series- parallel combination connection is more suitable. The weight applied on the tile and corresponding voltage generated is studied and they are found to have linear relation. It is especially suited for implementation in crowded areas. This can be used in street lighting without use of long power lines. It can also be used as charging ports, lighting of pavement side buildings.

REFERENCES

[1] Vibration Based Energy Harvesting Using Piezoelectric Material,M.N. Fakhzan, AsanG.A.Muthalif, Department of Mechatronics Engineering, International Islamic University Malaysia, IIUM,Kuala Lumpur, Malaysia.

[2] Piezoelectric Crystals: Future Source Of Electricity, International Journal of Scientific Engineering and Technology, Volume 2 Issue 4, April 2013Third Year Electronics Engineering, Atharva College of Engineering, Mumbai, India.

[3] Electricity from Footsteps, S.S.Taliyan, B.B. Biswas, R.K. Patil and G. P. Srivastava, Reactor Control Division, Electronics & Instrumentation Group And T.K. Basu IPR, Gandhinagar.

[4] Estimation of Electric Charge Output for Piezoelectric Energy Harvesting,LA-UR-04-

[5] Center for Intelligent Material Systems and Structures Virginia Polytechnic Institute and State University.

[6] Design Study of Piezoelectric Energy-Harvesting Devices for Generation of Higher Electrical Power Using a Coupled Piezoelectric-Circuit Finite Element Method IEEE Transactions on Ultrasonic's, Ferroelectrics, and Frequency Control, vol. 57, no. 2, February 2010.

[7] Meiling Zhu, Member, IEEE, Emma Worthington, and Ashutosh Tiwari, Member, IEEE 2449, Strain Journal, 40(2).

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