International Journal of
Composite and
Constituent Materials

ISSN: 2456-5237
Volume 8, Issue 1, 2022
DOI (Journal): 10.37628/IJCCM

http://materials.journalspub.info/index.php?journal=JCCM&page=index

Review IJCCM

Review of Piezoelecric Energy Harvesting Through Footsteps

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Abstract

In this modern world, growth of technology is highly increased and the human population. So, we have planned to connect these two things to harvest electrical power which is the ultimate source of all those technologies. This paper presents a literature review of generating power by using piezoelectric materials which converts human's footsteps into electrical energy. Many smart materials are used to generate power from many sources. In those, piezoelectric materials related papers are reviewed under the development of a device to produce electrical energy by using the pressure produced by the human while walking and jogging. The utilization of pressure obtained from compression of floors offered by human footstep pressure across the piezoelectric materials. The same technology is applicable for the long vibration system existing in the world.

Keywords: Piezoelectric material, Energy harvesting, Electric energy, Mechanical load, Human Population.

INTRODUCTION

A review on piezoelectric power generation has been performed by various authors from the year 2007 and numerous experiments and research had been performed by them. This paper reviews the work of various authors from the year 2018. The review focuses on the papers on power generations from piezoelectric materials [1-3]. This paper also reviews power generations from footsteps [1]. Generation of power from human footstep using piezoelectric materials is a greener way to develop electricity. Depends upon the material property the electricity production level can increase. Therefore, for day to day use this system can also produce a considerable amount of power. Recent improvements of technology in electrical and electronic devices, the need of electrical energy increases, and reduction of fossil fuels causes urge the need of other modes of electricity production. The increase in amount of pollution in current power generation process and less productivity effects need to compensate. This paper reviews the works should be done on piezoelectric transducers for power generation [4-7]. The use of sensors has increased in various fields and their use has been increased in piezoelectric power generations as well. This paper too reviews the use of piezoelectric sensors in power generations [8-12]. They are mainly used in power generations from footsteps [9]. The sensors are the easiest way to generate power from footsteps.

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Received Date: May 09, 2022
Accepted Date: May 21, 2022
Published Date: June 24, 2022

Citation: S. Usha, Rajeshwar P, Sasi Kumar S, Yeswanth K, Yugesh G. Review of Piezoelecric Energy Harvesting Through Footsteps. International Journal of Composite and Constituent Materials. 2022; 8(1): 14–18p.

Methods and Materials Used for Piezoelectric Energy Harvesting

The use of low power electronic device has been increased rapidly. These devices consume electricity in a large number and there is urgent need

in producing alternate renewable energy in human surroundings. This review paper tries to develop a piezoelectric generator which can produce electricity from vibrations e.g., walking vibration. This paper reviewed the piezoelectric energy harvesting model, which is cost-effective and easy to implement.

The depletion of fossil fuels has urged the need for alternate materials for harvesting electricity. We can achieve good mechanical flexibility, suitable voltage with sufficient power output by using polymeric piezoelectric composites for energy harvesting. This review paper explains about piezoelectric energy harvesting devices with specific material by focusing on the basic theory and principles. This study reviews the properties of different piezoelectric materials, composites and the performance characteristics of these materials have been reviewed by the author.

The measure of the power output is based on three parameters. They are size of the piezoelectric material, compression depth and the compression speed. The difference between the sizes of the piezoelectric ceramic is the main parameter used to analyze the power output. As compression depth increases, the power generation will increase. From this study efficient conditions were designed for maximum power generation.

Some materials showing piezoelectricity are tourmaline, quartz, topaz, cane sugar, and Rochelle salt. [2-3]. This piezoelectric phenomenon was first discovered by Physicist brothers Pierre and Jacques Curie. From their research they found that when some crystal's surface undergoes compression, then the crystal shows charge on some portion. This research was influenced by Pierre Curie's work on the pyroelectric effect, it is about the generation of electric potential in response to the temperature change. The pyroelectric material comes under the sub-groups of piezoelectric materials. The term "piezo" and "pyro" are Greek word which represents "to press" and "fire" respectively.[3]

Piezoelectric Sensors in Footsteps

This reviewed paper consists the design of power generation using footsteps by using available piezoelectric sensors. Power resources were worn out and enervated because of the human race in the world. This race consumes high energy with rapid rate. This proposal for the energy harvesting from foots of human is very much to the useful for extremely populated nations like China, India and United states. Especially over peopled places like streets, rail station. So, using the above concept the energy can be harvested and deployed by converting mechanical energy to electrical energy.

The ferroelectric materials group also has piezoelectric ceramics. Commonly used piezoelectric ceramics are, PbTiO3, PbZrO3, and PZT (Metallic oxide-based), PVDF [2]

Benefits of piezoelectric sensors:

1. It has the response of very high frequency.
2. No need of external source, because of self-generating.
3. It is simple to use because they have small dimensions and large measuring range.
4. In any proper shape and form barium titanate and quartz can be produced [1]. It also has a large dielectric constant. By orienting the direction of orientation, the crystal axis is selectable.

Limitations

1. In static condition, it is not suitable for measurement.
2. They need high impedance cable for electrical interface, when the device operates with the small electric charge.
3. According to the temperature variation of the crystal, the output may vary.
4. The relative humidity rises [1] above 85% or falls below 35%, its output will be affected. If so, it has to be coated with wax or polymer material.

Method to Harvest Electrical Power Through Footstep Power Generation

To develop method of producing electrical power from piezoelectric materials people are working on various processes. This reviewed paper contains clear methods that are commonly followed by various research. Piezoelectric materials are transducers which have been developed electrical power by receiving power. Here the pressure is in the form of footstep of the people is utilized. [1-5]

The listed points are commonly used in power generation across piezoelectric sensors.

- In proper connection piezoelectric sensors are fixed in rigid frame that should be stable when the human footstep power exists. (Some works contains the frame as Transparent acrylic sheets, corrugated cardboards, and wooden plies for testing purpose)
- n numbers of sensors are fixed across the frame to achieve high power across piezoelectric sensors.
- Property of frame should have like weather ability, strength, clarity, and versatility.
- The footstep interface used should be suitable.
- For Example. Chain sprocket arrangement and springs are used as footstep power generation
- When the pressure exists on the frame, the load transformation to the Piezoelectric sensors will convert into electrical energy. That electrical energy is processed to store in the battery.
- Diodes, capacitors, stable vibrators, investors, and batteries are used to process the electrical energy and convert that energy into DC. [2-5]

Power Harvesting and Energy Storing Process Using Battery

The AC voltage produced by ‘n’ number of piezoelectric sensors is converted into DC by using general purpose diode (like 1N4001 series). This is followed by capacitor and capacitor charged by rectifier. The charging threshold voltage of the capacitor is pre-determined. At specific voltage, switch closes then discharging will takes place. This is the way of storing energy in the capacitor. Based on the load capacitor is discharged. [10-13]

Outcome of Practical Analysis of the Footstep Power Generation System

AC waveform is the output of piezoelectric transducer. Sinusoidal transient pearls are generated by the visual materials that are placed in the 3D models. The output voltage is measured using oscilloscope of the piezoelectric transducer. Based on the center full sizes in 3D model the bending process of the piezoelectric transducer will changes. If there is no center hole in the system, then there will be no deflection can produce then the output voltage value also differs. It will be only 5.4 V in the AC form. If the hole is obtained in the piezoelectric system, then there will be few contractions or deflections can produce then voltage level also very. For 30 mm diameter hole can obtain output voltage as 19 V, similarly for 40 mm diameter can give output voltage as 34.4 V. Even though the piezoelectric material has a great property of converting the mechanical into electrical energy, there is less power output challenging one while generating the power.

This paper revels, the strategy to overcome the above-mentioned problems; they used the buzzer as the piezoelectric sensor. It has a little amount of piezo crystal in the surface. The thickness is comparatively less so these could break into pieces by the pressure exerted by human. Finally mechanical structure used to give the strength and helped to get maximum output in the range of megawatt from piezoelectric sensor. [14]

In 1 square ft. they were used 12 piezo sensors to generate power from piezoelectric sensor varies from different steps, they got for minimum output voltage as 1 V per footstep, similarly for maximum output voltage is obtained as 10.5 V per footstep.

For example, for average weight of 50 Kg pressure from single man. Taking the steps count for a 50 Kg weighted human, the average values can obtain as mentioned below.

Such as, for 800 steps used to increase 1V of charge into the battery. Therefore, to increase 12 V of charge in battery around 9600 steps needs to be obtained.

So, this work needs to implement in a high population area where more footsteps will be available, so in 1 second, they took an average of 2 steps.

So, time needed for 9600 steps (Approx.)

$$Time = \frac{9600}{(60\times2)} = 80\, min\, u\, tes$$

OUTCOME OF PRACTICAL ANALYSIS OF OTHER METHODS

Electrical Power Generation Using Piezoelectric Crystal

For an experimental testing a mobile power harvester is attached to a shaker. Nickel Metal Hydride batteries of 40 & 80 mAhr are used to demonstrate power harvesting and both the batteries are connected in parallel with actuators. With a frequency of 1.4Hz the charging of two 40 mAhr batteries took 3.09 hours and two 80 mAhr batteries took 5.64 hours. With an individual actuator duration taken for charging 40 mAhr batteries is 16.1 hours and duration taken for charging 80 mAhr batteries is 22.7 hours. On October 6, 2009, Hefer had done an experimental test with piezoelectric generator which was placed in the Route 4 - old coastal road of Israel. In that experimental test the piezoelectric generator produced electricity about 2,000 watt-hours. He done this experiment with a length of ten-meter strip of asphalt with a generator and batteries setup placed in the road. But the energetic and feasibility results do not reach the expected results from the first practical test. So, they went to Israel and meet a Technion from a company of, for finish the pilot project. Dr. Lucy Edery Azulay, Project manager from Innowattech explained about the generators which was developed by them and embedded about five centimeters beneath the upper layer of asphalt. Enlarging the project length to one kilometer in a single lane road could produce 200 KWh of energy. So, the four lane highway roads could produce about MWh generating the electricity by the way is sufficient to provide electricity over 2500 households. [15]

Piezoelectric Power Generator from Vibration

The designed device performs like an AC current generator when it vibrates mechanically. The PZT film undergoes cyclically between tensile and compressive stress due to time-varying change in mechanical stress which results in a time-varying generated the source of the AC current. An accelerator (SINOCERA CA-DR-1005) is attached to vibrator spindle, so the vibration strength, acceleration, amplitude, or velocity, can be measured and the strength signal is delivered to an output display unit, SINOCERA YE5932A vibrograph. At last, voltage signal from the testing sample is monitored by an oscillograph (TEK tronix TDS3014B). The resonance frequency is about 609 Hz and voltage signal value is 898 mV AC peak–peak demonstrated by Oscillograph. So, between alternate extremes of maximum displacement, PZT layer oscillates. This shows the voltage output is *U*peak-peak/2 = 449 mV under maximum displacement. By increasing load its voltage increases, up to 898 mV at 112 kΩ. For 21.4 K resistance the expected peak point of the power is 2.16 mW. And at the 2.16 mW power level, a 608-mV peak–peak AC voltage value is measured. [9]

CONCLUSION

Piezoelectric energy harvesting has become an extensive field of research in terms of power generation for the past two decades. This journal tries to explain the concepts of power generation using piezoelectric concepts and to acknowledge various research groups interested in doing research in this field. The continues research and development in the field of Piezoelectric research and development with various mechanical, chemical, electrical and chemical properties has increased the efficiency of power generation using piezoelectric materials. There has been interest in various researchers to produce greener power generation and they are working piezoelectric materials and concepts to harvest electricity. Currently, most of the topics we mentioned in these papers are in the research phase and they will be in practical use sooner. This paper also includes the work of power generation using

Piezoelectric transducers and sensors. Sensors make their impact in every field of use, so it is not a surprise they have their importance in piezoelectric power generation as well. Especially power generation using footsteps will be much easier with the use of sensors.

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