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# A Review on Energy Generation using Piezoelectric Material

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**Abstract:** A review on to generate electricity using piezoelectric material which includes the basic theoretical modeling of the electrical energy generation mechanism and optimization of the piezo-host system. It is shown that with proper configuration, a single piezo-film can generate enough electrical density that can be stored in rechargeable battery for later usage. This concept is also applicable to some large vibration sources which can find from nature. Basic this system uses piezo electric material.

**Keywords**: Energy generators, Piezoelectric generators, Piezoelectric materials.

## I: INTRODUCTION

In many technology branches the parameters monitoring of the parameters, applications or environment, in which an appliance operates is necessary in correct operating of the technical object. Monitoring system contains often tens or hundreds of sensors. Heating, ventilation and air condition system applied in building can be examples. Correct functioning of these systems is possible thanks to temperature monitoring in the particular places. In the case of big, multi-storey buildings, such monitoring is performed by installing a considerable number of sensors that must be powered.

The application of conventional powering of these sensors requires the use of either kilometers of the wire or hundreds of batteries. In the case of powering with batteries there is a necessity to replace these batteries, which increases operating cost of monitoring system and makes the whole system non eco-friendly. Among these types of applications, the most beneficial solution would be generating electric energy in a place where a sensor has been installed. In different scientific centers, these is a research being conducted concerning appliances that generate electric energy from mechanical vibrations in a place where a sensor is installed.

Among these materials one can single out piezoelectric materials that enable conversion of the mechanical energy to electric energy (direct piezoelectric effect) and from electric to mechanical (converse piezoelectric effect). A source of mechanical energy can be vibration that are often generated in monitored processes and are usually adverse. Piezoelectric materials are the basis of construction of generator prototype, whose target can be powering of sensors in wireless monitoring nets. The increasing of efficiency of generators designed so that more electric power can be generated , which is achieved by application of more and more advanced piezoelectric materials and by different generator designs.

Free play Energy Company (USA) has released a human-powered electricity generator for commercial sale in which power is generated by pushing up and down with foot on a step-action treadle. A similar, newly released portable energy source is a foot-powered device that allows individuals to pump out power at a 40-watt clip to charge its own internal battery, which is capable of providing a powerful jolt to car batteries and AC and DC devices. In another approach, if everyone had small magnets in their shoes and the paving slabs had inter-connected coils cast inside, all linked to batteries, electricity can be generated and the amount will depend on how many people are on the move.

## II: HISTORY

The piezoelectric effect was discovered in 1880 by the bothers Pierre Curie and Jacques Curie. They combined what they knew about piezoelectricity and about structures of crystals to demonstrate the effect with tourmaline, quartz, topaz, cane sugar and Rochelle salt. They found out that when a mechanical stress was applied on these crystals, electricity was produced and the voltage of these electrical charges was proportional to the stress.[11]

The converse effect however was discovered later by Gabriel Lippmann in 1881 through the mathematical aspect of the theory. These behaviors were labeled the piezoelectric effect and the inverse piezoelectric effect, respectively from the Greek word piezein, meaning to press or squeeze. The first applications were made during World War I with piezoelectric ultrasonic transducers .Now a days, piezoelectricity is used in everyday life.[11]

A piezoelectric sensor is a device that uses the piezoelectric effect to measure pressure, acceleration, strain or force by converting them to an electrical signal. Piezoelectric sensors have proven to be versatile tools for the measurement of various processes. They are used for quality assurance, process control and for research and development in many different industries it was only in the 1950s that the piezoelectric effect started to be used for industrial sensing applications. Since then, this measuring principle has been increasingly used and can be regarded as a mature technology with an outstanding inherent reliability. It has been successfully used in various applications, such as in medical, aerospace, nuclear instrumentation, and as a pressure sensor in the touch pads of mobile phones. In the automotive industry, piezoelectric elements are used to monitor combustion when developing internal combustion engines. The sensors are either directly mounted into additional holes into the cylinder head or the spark/glow plug is equipped with a built in miniature piezoelectric sensor.[7]

## III: PIEZOELECTRIC EFFECT

Piezoelectric materials can be natural or man-made. when a force is applied on a piezoelectric material, this result in the development of a charge in this material. The activating force can be caused by deforming its crystal lattice without fracturing its structure.[11]
When there is no applied stress, the material is in balance and the positive and negative charge is evenly distributed. During the application of force, the lattice of the piezoelectric material is changed slightly, whereby a charge imbalance is created, which results in a potential difference. This resulting voltage, can be as high as several thousand volts. Since the current is extremely small, the generated power is also limited.[11]

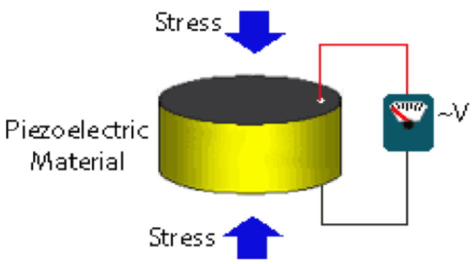


Fig1. A Simplified Graphical Representation of the Mechanism of the Direct Piezoelectric Effect electrical polarization of the material & the resulting voltage, are in proportion to the applied force.

Tension and compression generated voltages of opposite polarity. This principle, of creating a charge difference in response to applied stress, is known as the direct piezoelectric effect. The process whereby the piezoelectric effect takes place is based on the fundamental structure of a crystal lattice. Crystals generally have a charge balance where negative and positive charges precisely nullify each other out along the rigid planes of the crystal lattice. When this charge balance is disrupted by an external force, such as, applying physical stress to a crystal, the energy is transferred by electric charge carriers, creating a surface charge density, which can be collected via electrodes.[10]

**Examples of Piezoelectric Materials**:
The most commonly known piezoelectric material is quartz. But piezoelectric materials are numerous, the most used are:

- Quartz ($SiO2$): Quartz shows a strong piezoelectricity due to its crystalline structure, meaning that when a pressure is applied on a quartz crystal a electrical polarization can be observed along the pressure direction and Berlinite ($AlPO4$).
- Tourmaline: crystal commonly black but can range from violet to green and pink.
- Barium Titanate ($BaTiO3$): This element is an electrical ceramics; it is usually replaced by lead zirconatetitanate (PZT) for piezoelectricity. It is used for microphones and transducers.
- Lead ZirconateTitanate (PZT): It is considered today one of the most economical piezoelectric element, hence it is used in a lot of applications.
- Zinc oxide (ZnO), Aluminum Nitride (AiN)
- Polyvinylidene Fluoride (PVDF)

## IV: WORKING

A wide range of materials is available for the use in piezoelectric devices. The important criteria behind the selection of a material are Piezoelectric Voltage Constant, availability & productivity, cost effectiveness, sustainability. Considering the above mentioned factors Quartz is as most suitable which can be reclaimed most easily and is also abundant on earth‘s surface. Lead zirconate titanate (PZT) is also considered as one of the most economical piezoelectric materials because it is physically strong, chemically inert and relatively inexpensive to manufacture. Plus, it be easily tailored to meet the requirements of a specific purpose.[1]
PZT high piezoelectric charge constant (d33); a higher mechanical quality factor that reduces mechanical loss, a low dissipation factor that ensures cooler, more economical operation; high dielectric stability; and low mechanical loss under demanding conditions, a higher operating temperature than other Piezo ceramics. Piezoelectric materials are generally utilized for applications where there is a low power requirement. They include portable electronic devices such as mp3 players, mobile phones, GPS receivers or sensors of remote sensing systems or transmitters which are conventionally powered by batteries.[1] The amount of pressure required for distortion of a piezoelectric ceramic element by 0.05mm can generate nearly 100 kV, however the electric current generated is of the order of mA to µA. Key factors involved in the amount of energy produced by a piezoelectric material have to do with the stress on the element, which is the ratio of the applied force to the surface area of the element. When the composition of the ceramic, the volume of the ceramic element, and the applied force are constant, the element that has the smallest surface area will generate the most electrical energy.[2] Very high amounts of electric energy are

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obtainable with piezoelectric elements when the amount of stress applied to it is very high or very frequent. For example, a 2 kN force properly applied to a cubic-centimeter sized quartz crystal produces over 12.5 kV. The amount of energy will increase linearly with the amount of stress applied to it, so the more pressure there is on the piezoelectric material, the more power will be generated.[1] Whenever force is applied on piezo electric crystals that force is converted to electrical energy is used to drive DC loads. And that minute voltage which is stored in that lead Acid battery. The battery is connected the inverter. This inverter is used to convert the 12Volt D.C to 230 Volt A.C. This 230 Volt A.C voltage is used to activate the loads. We are using conventional battery charging unit also for giving supply to the circuitry.[4]

MATHEMATICAL ANALYSIS

As we know the pressure is directly proportional to amount of power generated

**P α Wt**

Here we take the constant of proportionality as Ƙ, then the equation becomes

**P = Ƙ Wt**

Where,

Ƙ- Constant of proportionality

Wt-weight, P-power

We know that for wt=50kg, we get the value of voltage V=4v and I =0.015A

Then P=V*I=4*0.015=0.06w, means we can say that for 50kg we get power (P) =0.06w

From this we can find the value of k

Ƙ=P/wt=0.06/50=0.0012

The table given below shows relation between P &wt

| Sr. No. | P in watt | Wt in kg |
|---|---|---|
| 1 | 0.012 | 10 |
| 2 | 0.024 | 20 |
| 3 | 0.06 | 50 |
| 4 | 0.09 | 75 |

Table No .1: Observations At Different Weight [4]

## V. ADVANTAGES

1.Reliable,Economical,Eco-friendly.
2.Less consumption of Non-renewable energies
3.Extremely wide dynamic range,almost free of noise– suitable for shock measurement as well as for almost imperceptible vibration.
4.Excellent linearity over their dynamic range,
5.Great variety of models available for nearly any purpose.
6.Easy replacement of equipments.
7.Simple to use as they have small dimensions and large measuring range

## VI. APPLICATIONS

1.Due to the intrinsic characteristics of piezoelectric materials, there is a wide range of applications such as sensors, actuators, crystal oscillator, ultrasonic application, piezo-motor etc.
2.Mates And People Powered Dance Clubs.
3. Highways and Gateways
5.Foot step generated power can be used for agricultural, home applications, street-lighting.
6. Power generation side walk.
7.Metros, Rural Applications, etc.

## VI. CONCLUSION

Thus we conclude that the energy generation using piezoelectric material can be used for many applications in rural areas where power ability is less or totally absence. As India is a developing country where energy management is a big challenge for huge population. By using this we can drive both A.C. as well as D.C loads according to the force we applied on the piezo electric sensor. Flexible piezoelectric materials are attractive for converting the ambient vibration energy surrounding them into electrical energy. Piezoelectricity offers a viable alternative to conventional fossil fuels. It is relatively inexpensive and easy to install, and recycles otherwise wasteful forms of energy. The efficiency is low, in the range of 20-30%. Further work in this field is required to find out more efficient methods of utilization. With further advancement in field of electronics, better synthesized piezoelectric crystals and better selection of place of installations, more electricity can be generated and it can be viewed as the next promising source for generating electricity.

## REFERENCE

[1]Anil Kumar (2011) ‘Electrical Power’ Generation Using piezoelectric crystals- International Journal of scientific and Engineering Research –Volume 2,Issue 5,May -2011 1.ISSN 2229-5518.
[2] NayanHabib in Renewable Energy and Power – In last few years low power electronics…. .879-904
[3] Japan for Sustainability. (2008, May 9). Power Generating Floor Tested at JR Tokyo Station. Retrieved November 30, 2008.
[4]S.Trolier-McKinstry,(2008)."Chapter3: Crystal Chemistry of Piezoelectric Materials".In A. Safari, E.K. Akdoˇgan. Piezoelectric and Acoustic Materials for Transducer Applications. New York: Springer. ISBN 9780387765389
[5] Richard, Michael Graham, (2006-08-04). "Japan: Producing Electricity from Train Station Ticket Gates". Tree Hugger. Discovery Communications, LLC.
[6] IEEE Standard on Piezoelectricity, Standards Committee of the IEEE Ultrasonic’s, Ferroelectrics, and Frequency Control Society, ANSI/IEEE Std 176-1987 (1988).
[7] Becker, Robert O; Marino, Andrew A, (1982). "Chapter 4: Electrical Properties of Biological Tissue (Piezoelectricity)". Electro magnetism & Life. Albany, New York: State University of New York Press. ISBN 0-87395-560-9.
[8] Andrew Townley, Electrical Engineering, University of Pennsylvania.
[9] JedolDayou, School of Science and Technology, University Malaysia Sabah, 88999 Kota Kinabalu, Sabah, Malaysia.
[10] Man-Sang, Faculty of Science, Art and Heritage, University Tun Hussein Onn Malaysia, 86400 Parit Raja, BatuPahat, Johor, Malaysia.
[11] ANSI-IEEE 176 (1987) Standard on Piezoelectricity.