International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume 2 Issue 4, pp : 260-262 1 April 2013

# Piezoelectric Crystals : Future Source of Electricity

**Pramathesh.T[1], Ankur.S[2]**

[1,2]Third Year Electronics Engineering, Atharva College of Engineering, Mumbai, India
[1] tpramathesh@gmail.com

## Abstract

***With the increase in energy consumption due to ever-growing number of electronic devices, the concept of harvesting renewable energy in human surrounding arouses a renewed interest. In this context, we have highlighted use of piezoelectricity and its generation. The other alternative thought is shared at the end.***

## Key words

Mechanical pressure, piezoelectric effect, piezoelectric, material, ferroelectrics, crystals thermocouple.

## I. INTRODUCTION

With the conventional source of generation of electricity being either polluting or non reusable (example. Coal, fossil fuels etc) search for a clean, reusable source of energy has caused a spike an interest in the exploration of piezoelectricity.

Piezoelectricity is appearance of electric potential across the sides of crystal when subjected to mechanical stress. Thus by making use of human movements and movements of automobiles, piezoelectricity can be generated to a commercially usable extent.

## II. FUNDAMENTALS OF PIEZOELECTRIC MATERIAL

The conversion of mechanical energy into electrical one is generally achieved by Dynamo - a convertor alternator. But there are other physical phenomena that can also convert mechanical movements into electricity, one of which is piezoelectricity.

The piezoelectric effect exists in two domains, the first is direct piezoelectric effect that describes the material's ability to transform mechanical strain into electrical charge, the second form is the converse effect, which is the ability to convert an applied electrical potential into mechanical strain energy.

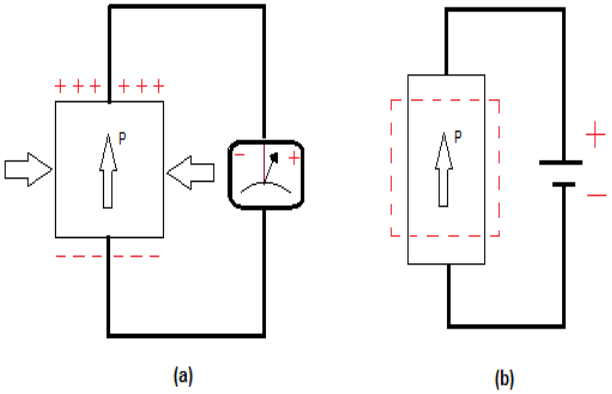


Fig. 1. Electromechanical conversion via piezoelectricity Phenomenon
(a)-Direct piezoelectric effect
(b)-Reverse piezoelectric effect

The direct piezoelectric effect is responsible for the materials to function as a sensor and the reverse piezoelectric effect is accountable for its ability to function as an actuator. A material is deemed piezoelectric when it has this ability to transform electrical energy into mechanical energy, and vice versa.

The piezoelectric materials that exist naturally as quartz, which possess properties for the production of electricity in very small quantity, however, compare to quartz, an artificial piezoelectric materials such as PZT (Lead Zirconate Titanate) present advantageous characteristics of generating more electricity.

Piezoelectric materials belong to class called ferroelectrics. One of the defining traits of a ferroelectric material is that the molecular structure is oriented such that the material exhibits a local charge separation, known as an electric dipole. Throughout the artificial piezoelectric material composition the electric dipoles are oriented randomly, but when a very strong electric field is applied, the electric dipoles reorient themselves relative to the electric field, this phenomena occurs in case of reverse piezoelectric effect.

When the material is deformed or stressed an electric voltage can be recovered along surface of the material (via electrodes).

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. [1]

## III. HARVESTING ENERGY FROM HUMANS

The human body contains enormous quantities of energy, for e.g. an average adult has a one-ton battery in the form of fats in present in the body. This energy is used as fuels for all activities. Piezoelectric effect can be used to generate electricity using such body energies to run smaller gadgets which consume less power. [2]

## IV. PRESENT USE OF TECHNOLOGY

Tiles made up of many layers of rubber sheeting, to absorb the vibrations and ceramic; underneath piezoelectric crystals are placed which can be used to generate electricity by movements on them. When such tiles are installed in locations where large crowd movements are expected like in Railway & Bus stations, Airports, Malls etc, and a person steps on them, than by piezoelectric effect small charge is built up on surface of crystals. Though energy generated by one person would be too less but if number of steps on such tiles increase than energy produced by it would increase too. One more way to increase energy by use of such tiles is to increase pressure on them i.e. to use them for road construction. When a person steps on such tiles piezoelectric crystal underneath it experiences mechanical stress which creates electric charge built up on crystal's surface which can be collected by use of electrodes. Such energy can be stored in capacitors and power can be channeled to energy deficient regions.

Japan has already started experimenting use of piezoelectric effect for energy generation by installing special flooring tiles at its capitals' two busiest stations. Tiles are installed in front of ticket turnstiles. Thus every time a passenger steps on mats, they trigger a small vibration that can be stored as energy.

Energy thus generated by single passenger multiplied by many times over by the 400,000 people who use Tokyo station on an average day, according to East Japan Railway, which generates sufficient energy to light up electronic signboards.

An average person weighing 60 kg will generate only 0.1 watt in the single second required to take two steps across the tile, but when they are covering a large area of floor space and thousands of people are stepping or jumping on them, then significant amount of power can be generated. This energy created is sufficient to run automatic ticket gates and electronic displays. [3]

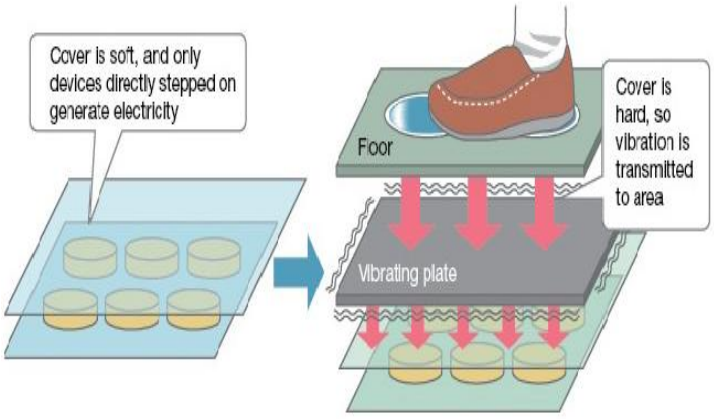


Fig.2.Special flooring tiles with piezoelectric crystals.

Constructing special types of roads that generates electricity just by driving over them is next step towards use of piezoelectric crystals. The system works by embedding tiny piezoelectric crystals into the road. When cars drive over such roads crystals embedded in them squeeze and thus generate a small electrical charge. Though small charge is generated by single car but 1 km stretch of such road could generate around 400kW-enough to run eight small cars. Such experimenting have already started in Israel. According to the Environmental Transport Association (ETA), if such system was installed on every stretch of British motorway it would generate enough energy to run 34,500 small cars. Certain vehicles could thus be powered entirely by road on which they drive. [4]

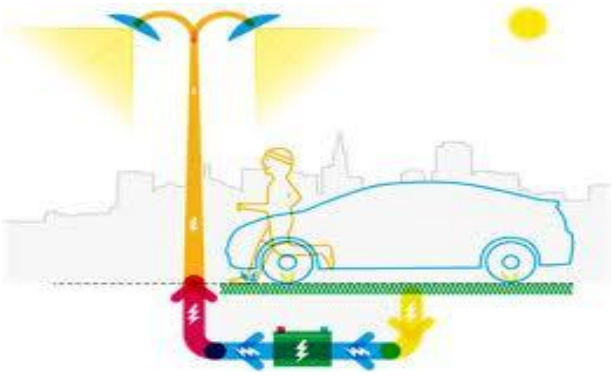

Fig.3.Specially designed road which generates electricity.

Apart from roads and railway stations, dance clubs are now a day making use of piezoelectric effect. In Netherlands, Rotterdam's new club WATT has a floor that harnesses the energy created by dancer's steps. Designed by Dutch company called the Sustainable Dance club, the floor is based on the piezoelectric effect. As club goers dance on floor, the floor is compressed by less than half an inch. It makes contact with the piezoelectric material under it and generates around 2-20 watts of electricity, depending on the impact of the dancers' feet.

Though at present, it's just enough to power LED light present in the floor, but in future, more output is expected from newer technology. In London, Surya, another new eco-nightclub, uses the same principle for its dance floor to generate electricity. [2]

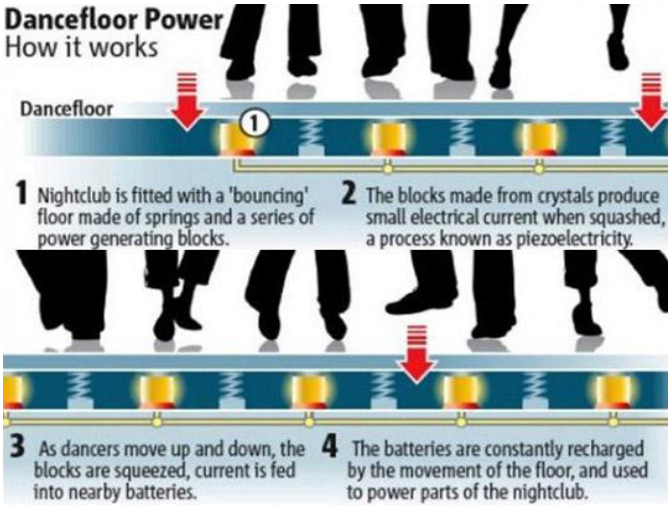


Fig.4.Dance floors with piezoelectric crystals installed.

Apart from tiles, roads and dance floors; attempts are made to harvest energy from our daily movements by installing piezoelectric crystals in shoes. Such shoes would have piezoelectric crystals at the rear end near heel. Thus with each step piezoelectric crystal would undergo compression which in turn can generate enough energy to power cell phones, mp3 players etc. Though more experimentations on such shoes are going on, and main hurdle is electricity generated is very less; thus attempts are made to increase power output of such shoes so that one's daily movements will be able to generate electricity enough to charge up small electronic gadgets.

Fig.5.Piezoelectric crystals installed in shoes.

## V. OUR THOUGHTS

In India, maximum public movements is observed in railways stations and holy places, hence, such places can be exploited for use of piezoelectric crystals for generation of electricity. Gathering ranging from thousands to millions are observed in holy places, thus installation of piezoelectric crystals at floorings would generate enough power to light up lights of temples as well as air circulation systems.

While studying use of piezoelectric crystals embedded in shoes and roads, idea struck in our mind that piezoelectric crystals can be replaced with small hydraulic pumps in heels of shoes and large pumps in case of bridges & roads. While stepping such hydraulic pumps at heel of our shoes would get compressed and this compressed air can be used to rotate small electric generators at heel of shoes. Thus our daily movement can be used to run small electric devices. Though such generators would be able to generate small power but on large scale i.e. if used in bridge construction than massive energy can be generated. Similarly by driving on such road & bridge, due to compression the hydraulic pump can to rotate generators in turn generate electricity.

Other idea that struck our mind while studying alternative source of energy was use of thermocouple to generate electricity. In regions where temperature falls below zero degree, use of thermocouple can be implemented to generate electricity. Idea is to use human body as a hot junction while atmospheric temperature as cold junction. Thus thermocouple in form of jackets can be used with thermal insulation between hot plate in contact with human body (specifically chest and back because human body emit more heat from chest compared to other part of body) and cold junction (exposed as external surface).Though small voltage in range of millivolts could be generated with temperature difference of 50° C by use of type T thermocouple which can be experimented to get more output.

Though this is just our ideas, real implementation and conceptualization would require some time and efforts on our part.

## VI. CONCLUSION

Use of piezoelectric crystals has being started and positive results are obtained. 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 a next promising source of generating electricity.

## VII. ACKNOWLEDMENT

Images and information sourced from www.google.co.in.

## VIII. REFERENCES

[1] E. Minazara, D. Vasic and F. Costa," Piezoelectric Generator Harvesting Bike Vibrations Energy to Supply Portable Devices".

[2]Scilll staff, "Harvesting Energy from Humans", www.popsci.com, Jan 09.

[3] J. Ryall, "Japan Harnesses Energy from Footsteps," The Telegraph, 12 Dec 08.

[4]Kenneth Hall, "Israeli firm developing electricity-generating road", www.motorauthority.com, Dec 08.