International Journal Of Advanced Research In Engineering Technology & Sciences
ISSN: 2394-2819
Email: editor@ijarets.org
April- 2015 Volume 2, Issue-4
www.ijarets.org

Power Generation by Incorporation of Piezoelectric Materials

Rahul Dadhich, Shubham Bansal, Jeeveh Idnani, Aviraj Gupta
Department of Civil Engineering
SRM University NCR Campus
Ghaziabad

ABSTRACT

The recent fluctuations on the price of petroleum have affected worldwide economics which has forced an increased in the price of other items including food. Some even linked the recent collapse of few financial institutions in countries such US and the UK to the recent increased in this price. This shows that we are too dependent to petroleum as a source of electrical power. As a consequence, other possible energy sources must again be explored.

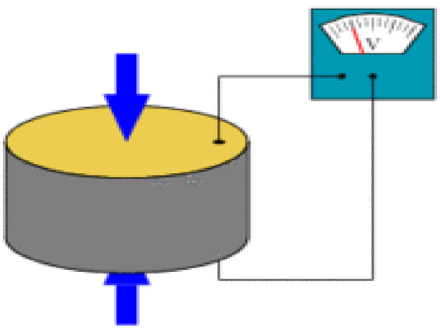
One of the promising options is by using piezoelectric material. Piezoelectric materials can be used as a mechanism to transfer ambient vibrations into electrical energy. This energy can be stored and used to power up electrical and electronics devices. The application of piezoelectric as a power generator can be extended to operate daily low power electrical appliances such as tuner, light bulb, mobile phone and so on. The aim of this paper is to develop the piezoelectric material as a power generator for these applications.

INTRODUCTION

PIEZOELECTRICITY

Piezoelectricity is the electric charge that accumulates in certain solid materials (such as crystals, certain ceramics, and biological matter such as bone, DNA and various proteins) in response to applied mechanical stress. The word *piezoelectricity* means electricity resulting from pressure. It is derived from the Greek *piezo* or *piezein*, which means to squeeze or press, and *electric* or *electron*, which means amber, an ancient source of electric charge. Piezoelectricity was discovered in 1880 by French physicists Jacques and Pierre Curie.

Piezoelectricity (also called the piezoelectric effect) is the appearance of an electrical potential (a voltage, in other words) across the sides of a crystal when you subject it to mechanical stress (by squeezing it).



MECHANISM

The nature of the piezoelectric effect is closely related to the occurrence of electric dipole moments in solids. The latter may either be induced for ions on crystal lattice sites with asymmetric charge surroundings (as in $BaTiO_3$ and PZTs) or may directly be carried by molecular groups (as in cane sugar). The dipole density or polarization (dimensionality $[Cm/m^3]$) may easily be calculated for crystals by summing up the dipole moments per volume of the crystallographic unit cell. As every dipole is a vector, the dipole density ***P*** is a vector field. Dipoles near each other tend to be aligned in regions called Weiss domains. The domains are usually randomly oriented, but can be aligned using the process of *poling* (not the same as magnetic poling), a process by which a strong electric field is applied across the material, usually at elevated temperatures. Not all piezoelectric materials can be poled.

1. Normally, the charges in a piezoelectric crystal are exactly balanced, even if they're not symmetrically arranged.
2. The effects of the charges exactly cancel out, leaving no net charge on the crystal faces. (More specifically, the electric dipole moments—vector lines separating opposite charges—exactly cancel one another out.)
3. If you squeeze the crystal (massively exaggerated in this picture!), you force the charges out of balance.
4. Now the effects of the charges (their dipole moments) no longer cancel one another out and net positive and negative charges appear on opposite crystal faces. By squeezing the crystal, you've produced a voltage across its opposite faces—and that's piezoelectricity!

Piezoelectric materials

Piezoelectric materials are used for making devices that convert mechanical forces into electrical signals (direct piezo effect), electrical signals into mechanical forces (inverse piezo effect), or electrical signals into electrical signals (successive use of direct and inverse effects). Piezoelectric materials are ferroelectric compositions and their solid solutions, which are made by the synthesis (thermal treatment) of a mixture of different oxides, carbonates and salts of metals

Many materials, both natural and synthetic, exhibit piezoelectricity:

Naturally occurring crystals

- Quartz
- Berlinite ($AlPO_4$), a rare phosphate mineral that is structurally identical to quartz
- Sucrose (table sugar)
- Rochelle salt
- Topaz
- Tourmaline-group minerals
- Lead titanate ($PbTiO_3$). Although it occurs in nature as mineral macedonite, it is synthesized for research and applications.

Advantages and Disadvantages of Piezoelectric Materials

Advantages:- They generate a voltage proportional to the velocity at which the crystal is deformed so require no local power source.

Disadvantages;- They have high impedance and can pick up stray voltages in the connecting wires. The crystal is also prone to cracking if overstressed.

Overview

The days when piezoelectric energy harvesting was considered unreliable and had low power output are long gone. Hand in hand with the development of ultra low power electronics, energy harvesters have been drastically improving also. In only a few years, piezoelectric harvesters moved on from harvesting power of the order of µW to devices demonstrated in 2008 harvesting mW. Development of roads and highways are just some of the most common construction projects that a city experiences every year. Even if there are no new roads to build and pave, maintaining other roads in working order is still an important task. But while engineers are worrying about improving the quality of the pavement as they build roads, scientist and researchers are actually thinking of ways on how to generate power from it.

International Journal Of Advanced Research In Engineering Technology & Sciences ISSN: 2394-2819
Email: editor@ijarets.org April- 2015 Volume 2, Issue-4 www.ijarets.org

The property of piezoelectric materials to produce electricity on compression is employed to harness energy of vehicles moving on roads by making the roads "PIEZO-SMART". This revolutionary new surface uses piezoelectric crystals embedded in the asphalt to generate up to 400 kilowatts of energy from a 1 kilo meter stretch (a design, devised by Haim Abramovich, a developer at the Teknion-Israel Institute of Technology in Haifa, Israel) enough to run eight electric cars. A kilo meter of "Piezo-smart road" could generate enough power for 40 houses, and progress in the technology could generate enough electricity to feed the national power grid. Private companies were competing in this sector but recently governments of developed countries are also taking notice to the developments in turning traffic rush into electricity and are funding many projects. **Our project analyses the effects of using piezoelectric materials with cement. The project focuses on the replacement of sand from cement mortar with Rochelle's Salt. This can be easily viewed as the use of piezoelectric material in a rigid pavement road rather than in asphalt based one.**

Technical Details

As mentioned earlier, this project makes use of Rochelle's Salt as the piezoelectric material. The salt is used in place of sand in the mortar. The project is aimed at analysing the effects of replacing sand with Rochelle's Salt both electrically and structurally. The changes include the presence of a potential difference, variations in consistency, initial setting time, final setting time and the compressive strength of the mortar.

Electrical Change

There is only one electrical change in the mortar in which, at the moment, we are interested in, is the appearance of a potential difference.

Structural changes

The structural changes that can be observed after the replacement of Rochelle's Salt with sand in the cement mortar are the variations in consistency, initial setting time, final setting time and compressive strength of the paste.

There is an excellent change in property of cement . By addition of Rochelle Salt in cement its Initial Setting Time reduces ,Hence making it a great Accelerator.

Chemical Used

Potassium sodium tartrate Potassium sodium tartrate is a double salt first prepared (in about 1675) by an apothecary, Pierre Seignette, of La Rochelle, France. As a result the salt was known as Seignette's salt or Rochelle salt. Rochelle salt is not to be confused with *rock salt*, which is simply the mineral form of sodium chloride. Potassium sodium tart rate and monopotassium phosphate were the first materials discovered to exhibit piezoelectricity. This property led to its extensive use in "crystal" gramophone (phono) pick-ups, microphones and earpieces during the post-War consumer electronics boom of the mid-20th Century. Such transducers had an exceptionally high output with typical pick-up cartridge outputs as much as 2 volts or more. Rochelle salt is deliquescent so any transducers based on the material deteriorated if stored in damp conditions.
It is a colourless to blue-white salt crystallizing in the orthorhombic system. Its molecular formula is $KNaC_4H_4O_6 \cdot 4H_2O$. It is slightly soluble in alcohol but more completely soluble in water. It has a specific gravity of about 1.79, a melting point of approximately 75 °C, and has a saline, cooling taste. As a food additive, its E number is **E337**.
It has been used medicinally as a laxative. It has also been used in the process of silvering mirrors. It is an ingredient of Fehling's solution and Nylander's test, formerly used in the determination of reducing sugars in solutions.
In organic synthesis, it is used in aqueous workups to break up emulsions, particularly for reactions in which an aluminium-based hydride reagent was used.
It is a common precipitant in protein crystallography and is also an ingredient in the Biuret reagent which is used to measure protein concentration. This ingredient maintains cupric ions in solution at an alkaline pH.

CONCLUSION

By studying both the electrical and structural changes in the building materials by addition of piezoelectric materials, we came to the conclusion that a considerable amount of voltage can be generated across the cement block and Rochelle salt in cement acts as a admixture (accelerator) that that fasten the setting process of cement. Hence such cement can be used in various sites which require less setting time period(marine works etc.) and can be useful in providing an eco-friendly and efficient way to generate electricity too**.**

REFERENCES

1. Wikipedia; en.wikipedia.org
2. Elpa Company; www.elpapiezo.ru
3. PCB Piezotronics; www.pcb.com
4. IDTechEx; www.idtechex.com
5. Priyanshu Kumar; Piezo-Smart Roads, International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
6. Vol. 2 Issue 6, June-2013, pp: (65-70) The Environmental Blog; www.theenvironmentalblog.org