NON-CONVENTIONAL ENERGY SOURCE USING PIEZOELECTRIC MATERIALS

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ABSTRACT

Now day's use of energy is increasing day by day and for that we have to develop different methods for producing energy for it. For that purpose we have to use the sources like solar, wind, pressure for production of energy. Piezoelectric materials are excellent pressure power generation devices because of their ability to couple mechanical and electrical properties. In this study paper we are representing the electrical power generation using human footstep. This is about how we can generate electricity using human's waste foot energy and applications for the same. When human walk in surroundings some force exerts on surface this force can be used to generate electricity. The idea of converting pressurize weight energy into the electrical energy is possible by Piezo-electric crystal.

Keywords: Pressure, Piezo-effect, Power Generation

I. INTRODUCTION

The one of major source of external energy which can used to separate outer orbit electrons away from their parent atom is pressure. Whenever you speak into a telephone or any similar type of microphone, the pressure waves of the sound energy which your voice generates make a diaphragm move. This diaphragm movement can be used to give rise to an electric charge in the following away. There exit in nature certain materials whose crystals develop an electric charge when pressure (as form a moving diaphragm) is exerted

or them. Quartz, tourmaline and Rochelle salts are examples. If a crystal from one of the material is placed between two metal plates and pressure is exerted on the plates, an electric charge will be created between the plates. It size will depend on the amount of pressure exerted.

It is also possible to convert electrical energy back into mechanical energy by placing an electric charge on the plates of such a device. The crystal will then expand or contract by a small amount, depending on the amount and type of the charge applied; and the mechanical energy so created can also be put to use Appearance of an electric field in certain non-conducting crystals as a result of the application of mechanical pressure. Pressure polarizes some crystals, such as quartz, by slightly separating the centers of positive and negative charge. The resultant

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electric field is detectable as a voltage. The converse effect also occurs: an applied electric field produces mechanical deformation in the crystal. Using this effect, a high-frequency alternating electric current (see alternating current) can be converted to an ultrasonic wave of the same frequency, while a mechanical vibration, such as sound, can be converted into a corresponding electrical signal. Piezoelectricity is utilized in microphones, phonograph pickups, and telephone communications systems. The application of a mechanical stress produces in certain dielectric (electrically non-conducting) crystals an electric polarization (electric dipole moment per cubic meter) which is proportional to this stress. If the crystal is isolated, this polarization manifests itself as a voltage across the crystal, and if the crystal is short-circuited, a flow of charge can be observed during loading.

Conversely, application of a voltage between certain faces of the crystal produces a mechanical distortion of the material. This reciprocal relationship is referred to as the piezoelectric effect. The phenomenon of generation of a voltage under mechanical stress is referred to as the direct piezoelectric effect, and the mechanical strain produced in the crystal under electric stress is called the converse piezoelectric effect. See also Polarization of dielectrics.

The necessary condition for the piezoelectric effect is the absence of a center of symmetry in the crystal structure. Of the 32 crystal classes, 21 lacks a center of symmetry, and with the exception of one class, all of these are piezoelectric. Hydrostatic pressure produces a piezoelectric polarization in the crystals of those 10 classes that show pyroelectricity in addition to piezoelectricity. See also Crystallography Pyroelectricity. Piezoelectricity is the ability of some materials (notably crystals and certain ceramics, including bone) to generate an electric field or electric potential in response to applied mechanical stress. The effect is closely related to a change of polarization density within the material's volume. If the material is not short-circuited, the applied stress induces a voltage across the material. The word is derived from the Greek Piezo or piezein, which means to squeeze or press.

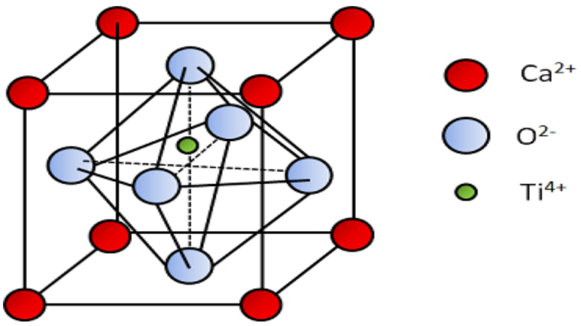

Fig.1 A Perovskite unit cell showing the off-centered titanium ion.

A typical noncentrosymmetric crystal structure such as a perovskite (calcium titanate — $CaTiO_3$) has a net non-zero charge in each unit cell of the crystal. However, as a result of the titanium ion sitting slightly off-center inside the unit cell, an electrical polarity develops, thereby turning the unit cell effectively into an electric dipole. A mechanical stress on the crystal further shifts the position of the titanium ion, thus changing the polarization strength of the crystal. This is the source of the direct effect. When the crystal is subjected to an electric field, it also results in a relative shift in the position of the titanium ion, leading to the distortion of the unit cell and making it more (or less) tetragonal. This is the source of the inverse effect.

II.EXPERIMENTATION

1 STUDY OF PIEZO MATERIAL

Piezoelectric ceramics belong to the group of ferroelectric materials. Ferroelectric materials are crystals which are polar without an electric field being applied. The piezoelectric effect is common in piezo ceramics like $PbTiO_3$, $PbZrO_3$, PVDF and PZT. The main component of the project is the piezoelectric material. The proper choice of the piezo material is of prime importance. For this, an analysis on the 2 most commonly available piezoelectric material - PZT and PVDF, to determine the most suitable material was done. The criterion for selection was better output voltage for various pressures applied. In order to understand the output corresponding to the various forces applied, the V-I characteristics of each material namely, PZT and PVDF were plotted. For this the Piezo transducer material under test is placed on a Piezo force sensor. Voltmeters are connected across both of them for measuring voltages and an ammeter is connected to measure the current. As varying forces are applied on the Piezo material, different voltage readings corresponding to the force is displayed.

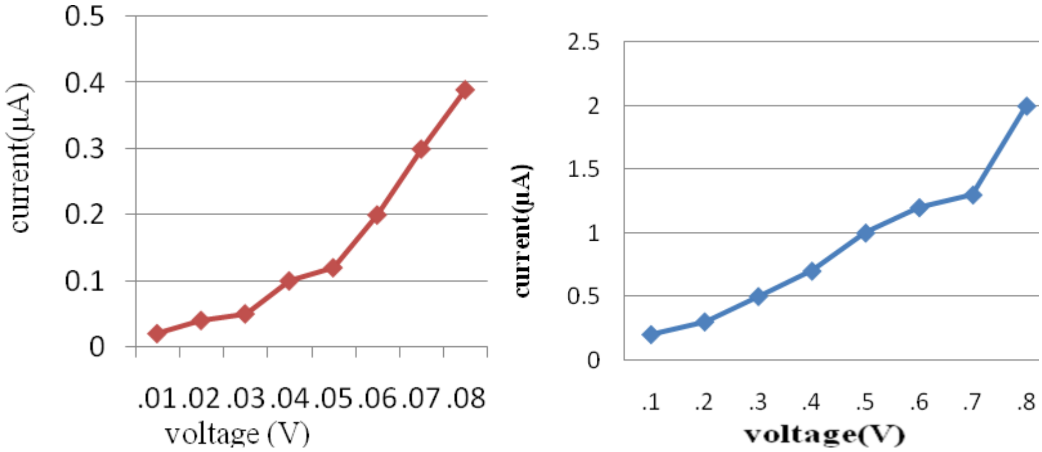

Fig.1a Fig.1b

Fig. 1a & 1b v-i graphs of pvdf & pzt materials

2 STUDY OF CONNECTIONS

Next to determine the kind of connection that gives appreciable voltage and current necessary, three PZT are connected in series.

A force sensor and voltmeter is connected to this series combination. As varying forces are applied on this connection, corresponding voltages are noted. Also the voltage generated across the series connection and the current is measured. Similarly the connections are done for parallel and series-parallel connections are done and the graphs are as in figures 2a and 2b.

It can be seen from the graph that the voltage from a series connection is good but the current obtained is poor, where as the current from a parallel connection is good but the voltage is poor. But this problem is rectified in a series- parallel connection where a good

voltage as well as current can be obtained.

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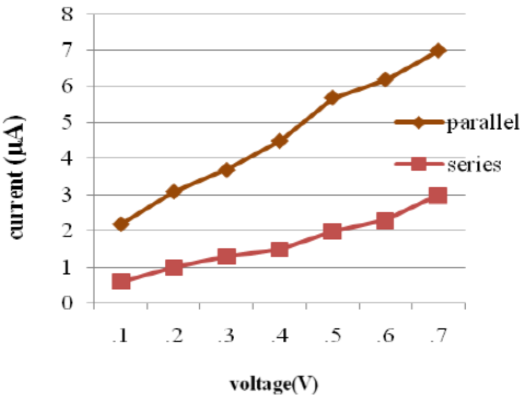

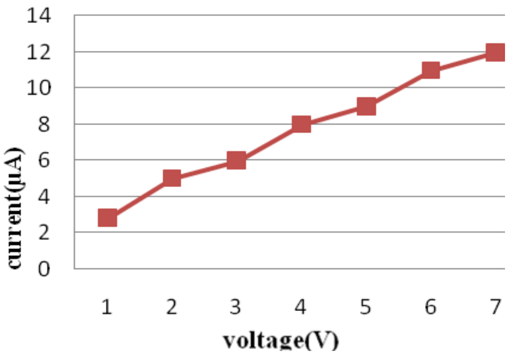

Fig.2a Fig.2b

FIG. 2a & 2b shows Individual & Combine Graph Of Parallel & Series Connection

III. 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 piezofilm 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.

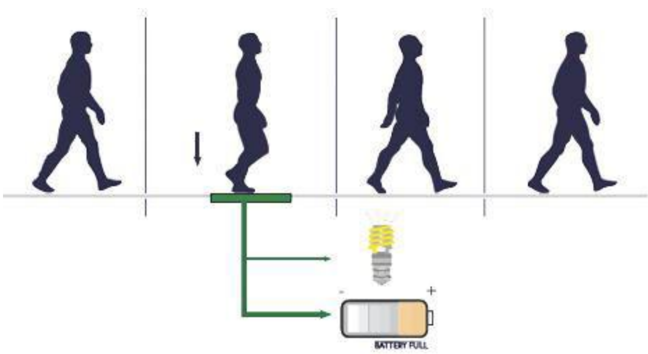

Fig.3 Schematic representation of the working model

IV.ANALYSIS DONE ON 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.

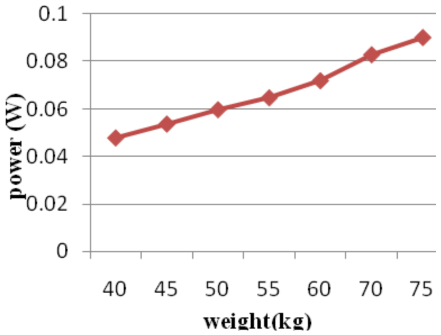

Fig.4 Weight V/s power graph of piezo tile

V.RESULTS AND DISCUSSION

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 in buildings.

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