DESIGN AND FABRICATION OF FOOT STEP POWER GENERATION USING PIEZO ELECTRIC TRANSDUCERS

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***ABSTRACT*: The concept is to capture the normally lost energy surrounding us. And convert it into electrical energy that can be used to extend the lifetime of an electronic devices. One of the most interesting methods of obtaining the energy surrounding a system is to use piezoelectric materials. There exists variety of energy harvesting techniques but mechanical energy harvesting happens to be the most prominent. This technique utilizes piezoelectric components where deformations produced by different means are directly converted to electrical charge via piezoelectric effect.**

Subsequently the electrical energy can be regulated or stored for further use. The proposed work in this research recommends Piezoelectricity as an alternate energy source. The motive is to obtain a pollution-free energy source and to utilize and optimize the energy being wasted.

Therefore the aim is to generate electric energy by walking and to store in a battery and utilize the stored energy when required. To improve this concept practically, a prototype module is constructed with spring loaded type mechanical structure, which is aimed to generate energy whenever some force is applied to its surface.

In this project we are generating electrical power as non-conventional method by simply walking or running on the foot step. Non-conventional energy system is very essential at this time to our nation. Non-conventional energy using foot step is converting mechanical energy into the electrical energy.

***Keywords*: piezo electric, transducers, voltmeter.**

I.INTRODUCTION:

1.1 Fundamentals of piezoelectric material

Piezoelectricity is the ability of some materials (notably crystals and certain ceramics) to generate an electrical potential in response to applied mechanical stress. This may take the form of a separation of electric charge across the crystal lattice. If the material is not short circuited, the applied charge induces a voltage across the material. The word is derived from the Greek word piezien, which means to squeeze or press. The conversion of mechanical energy into electrical one is generally achieved by converters alternator type or commonly known dynamo. But there are other physical phenomena including piezoelectricity that can also convert mechanical movements into electricity. The phenomenon that produces an electric charge when a force is applied to piezoelectric material is known as the piezoelectric effect. The piezoelectric effect exists in two domains, the first is the 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 figure.

The direct piezoelectric effect is responsible for the materials ability to function as a sensor and the converse 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 strain energy, and likewise transform mechanical strain energy into electrical charge. The piezoelectric materials that exist naturally as quartz were not interesting properties for the production of electricity, however artificial piezoelectric materials such as PZT (Lead Zirconate Titanate) present advantageous characteristics. Piezoelectric materials belong to a larger class of materials 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.

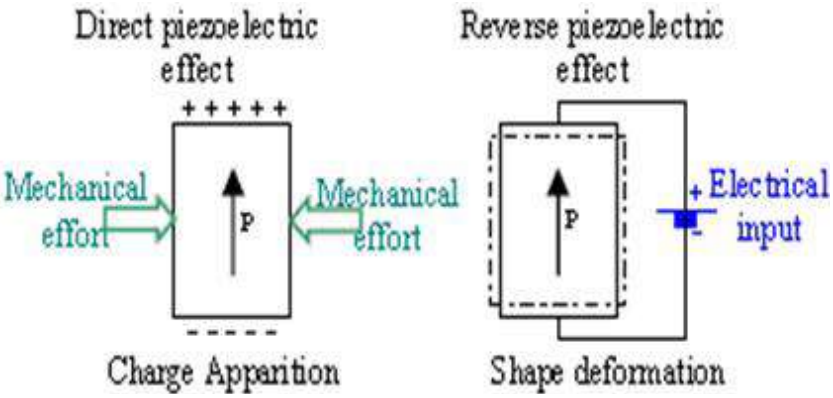


Fig1 Electromechanical conversion via piezoelectricity phenomenon

Throughout the artificial piezoelectric material composition the electric dipoles are orientated randomly, but when a very strong electric field is applied, the electric dipoles reorient themselves relative to the electric field; this process is termed poling. Once the electric field is extinguished, the dipoles maintain their orientation and the material is then said to be poled. After the poling process is completed, the material will exhibit the piezoelectric effect. The mechanical and electrical behaviour of a piezoelectric material can be modeled by two linearized constitutive equations. These equations contain two mechanical and two electrical variables. The direct effect and the converse effect may be modeled by the following matrix equations:

Direct Piezoelectric Effect: $D = d \cdot T + \varepsilon T \cdot E$ (1)

Converse Piezoelectric Effect: $S = sE \cdot T + dt \cdot E$ (2)

Where D is the electric displacement vector, T is the stress vector, εT is the dielectric permittivity matrix at constant mechanical stress, sE is the matrix of compliance coefficients at constant electric field strength, S is the strain vector, d is the piezoelectric constant matrix, and E is the electric field vector. The subscript t stands for transposition of a matrix. When the material is deformed or stressed an electric voltage can be recovered along any surface of the material (via electrodes). Therefore, the piezoelectric properties must contain a sign convention to facilitate this ability to recover electric potential.

1.2 Objectives of the Study

The aim of this research is to harvest energy from footstep using piezoelectric disk based on the concept of polarization. The objectives of the study are as follow:-

1) To produce renewable electricity from footstep using piezoelectric disk placed along a pathway.

2) To reduce the cost for power generation besides increasing the efficiency of power generation

1.3 Scope of the Study

Piezoelectric sensors would be arranged in two orders, series and parallel. This is to ensure there would be sufficient generation of electricity. The output be measured using a multimeter and a row of light emitting diode would be placed to indicate the presence of electricity.

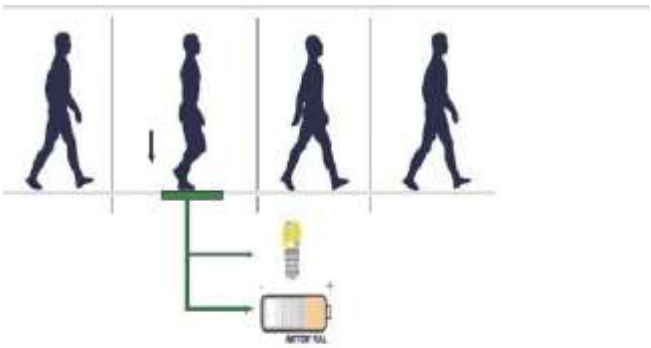
1.4 Significance of the Study

At the end of this research, we would be able to produce electricity in a minimal scale. This energy would be used as a secondary power sources to battery. Beside that, we can reduce the total cost of electricity application. In addition, the maintenance of piezoelectricity is minimal. The life span of a piezoelectric disk is also relatively long.

II.MATERIALS AND METHODS:

A. **MATERIALS**: PZT, or lead zirconate titanate, is one of the world's most widely used piezoelectric ceramic materials. PZT is composed of the two chemical elements lead and zirconium combined with the chemical compound titanate. The underside of the electrode is made up of plastic. A very thin layer of ceramic (SiO_2) is deposited on the outermost layer of the plastic. The ceramic element converts the mechanical energy of compression into electrical energy. The ceramic is a conductor material that acts as the negative terminal while the metal acts as the positive terminal. The interaction between the ceramic and the metal works in two ways: if outside electrical current is supplied, then the piezo will produce sounds. This property allows them to be used as buzzers and simple speakers. However, if no outside current is supplied and instead the piezo is subjected to changes in pressure (such as by the vibrations of guitar strings), then the interaction of the metal and ceramic actually creates a small amount of electrical current. The ceramic layer acts as the negative terminal meanwhile the metal acts as positive terminal

B. **METHODS:**



III.EXPERIMENTAL WORK:

3.1 Dimensions of MS-Plate

Length of the MS-Plate =290mm

Breadth of the MS-Plate =270mm

Thickness of the MS-Plate =3mm

3.2 Dimensions of piezo disc

Each piezoelectric disc =40×1 mm

3.3 Dimensions for support

Threaded rod (stud) =8×100 mm

Hexagonal nuts = 8mm (ID)

Springs = 10×100 mm

Pitch of the spring =2 mm

Wooden block = 260×250 ×30 mm

3.4 Specifications of spring

Material : stainless steel

Weight on the spring(W) : 75 kg

Mean diameter (D) : 8.5mm

Dia of coil (d) : 1 mm

Modulus of rigidity (G) : 70kN/mm^2

Piezo-resistive effect

Piezo-resistive effect is described as the changes in the electrical resistivity of a semiconductor when mechanical stress is applied without affecting the electrical potential. Assumption: Mass of 75kg was used as a control for the calculations

Mathematical analysis

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

$$P \alpha Wt \quad \text{.....} \quad (i).$$

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

P = Ҟ Wt

Where, Ҟ- 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 Ҟ

K=P/wt =0.06/50 =0.0012

The table given below shows relation between P & wt

SR.NO	P in Watts	WT in Kgs
1	0.012	10
2	0.024	20
3	0.060	50
4	0.075	60
5	0.090	75

Table-1 Power analysis

V.RESULTS AND DISCUSSIONS

The results obtained after testing various parameters on piezoelectric disc were discussed below:

5.1 Power generation on basis of load

While testing the prototype with different loads applied on it, there is variation in voltage. This variation in voltage with respect to loads can be shown by the graphical representation

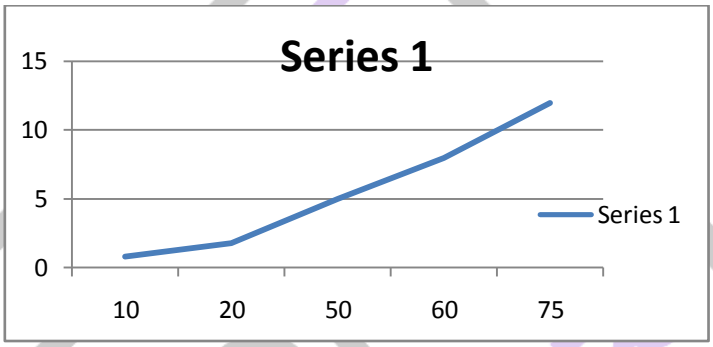


Fig 10.1 Graph: weight Vs volts

The above graph gives the overall view of the voltage generated throughout the project. The above graph represents weight Vs voltage generated.

After several attempts and failures in order to generate the voltage for the piezoelectric disc, a final voltage of nearly 15v is generated.

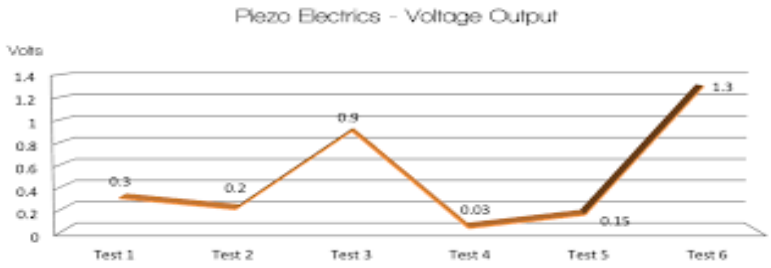


Fig 10.2 Graph on number of tests

Through the excitation of a piezoelectric disc, it is demonstrated that a 40 mAh battery can be charged in less than half an hour at resonance or in only a few hours

Fig 10.3 Multimeter

5.2 Future scope

Growing population which is considered to be a bane is used advantageously with piezo application. In an era where the significance of renewable energy is well proved, piezoelectricity is a promising alternative source of energy. At present the usage of piezoelectricity seems far from practicality for portable gadgets. But designers concerned about the energy crisis are working to enhance its utility for portable gadgets and beyond. Piezoelectricity shall definitely have huge impact in near future. At present it finds numerous applications, which will increase further owing to the desirable characteristics of the technology

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.

A non-conventional, non-polluting form of energy can be harvested, maintaining the economic standards of common laymen. The electricity is produced from the mechanical stress on the crystals due to piezoelectric effect and thus it generates the energy needed for charging battery to light streetlights at night and also for the city consumption of electricity. Regardless of this project, the future of piezoelectric materials looks bright, with studies focusing on their properties and applications even in nanotechnology.

If a compromise between the hardness of the road and the make-up of the small devices is reached, then undoubtedly the system will benefit both drivers and the national power grid. The assembly developed using series and parallel combination of piezo-crystals is very cost effective. A single crystal costs around 23 – 25 Rupees, and hence the cost of whole assembly is very less. It is very encouraging to get a good voltage and current at such a low cost at the same time utilizing the waste energy.

So, the assembly improves on the concern of cost effectiveness to a great extent and the work is on to further improve upon the results of the system.

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