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Footstep Power Generation Using Piezo Electric Transducers

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ABSTRACT: Man has needed and used energy at an increasing rate for the sustenance and well-being since time immemorial. Due to this a lot of energy resources have been exhausted and wasted. Proposal for the utilization of waste energy of foot power with human locomotion is very much relevant and important for highly populated countries like India where the railway station, temples etc., are overcrowded all round the clock .When the flooring is engineered with piezo electric technology, the electrical energy produced by the pressure is captured by floor sensors and converted to an electrical charge by piezo transducers, then stored and used as a power source. And this power source has many applications as in agriculture, home application and street lighting and as energy source for sensors in remote locations.

KEYWORDS: Piezoelectricity,PZT, PVDF, Inverter, Rectifier

I. INTRODUCTION

At present, electricity has become a lifeline for human population. Its demand is increasing day by day. Modern technology needs a huge amount of electrical power for its various operations. Electricity production is the single largest source of pollution in the whole world. At one hand, rising concern about the gap between demand and supply of electricity for masses has highlighted the exploration of alternate sources of energy and its sustainable use. On the other hand, human population all over the world and hence energy demand is increasing day by day linearly. Accordingly, it is an objective of the present invention to provide a method of electrical power generation from this ever increasing human population that does not negatively impact the environment. This technology is based on a principle called the piezoelectric effect, in which certain materials have the ability to build up an electrical charge from having pressure and strain applied to them. Piezoelectricity refers to the ability of some materials to generate an electric potential in response to applied pressure. Harvesting of energy which means energy is already available, but is going to waste if not utilized. Embedded piezoelectric material can provide the magic of converting pressure exerted by the moving people into electric current.

II. RESEARCH ELABORATIONS

STUDY OF PIEZO MATERIALS-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 PbTiO3, PbZrO3, 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

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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. For each such voltage reading across the force sensor, various voltage and current readings of the Piezo test material are noted.

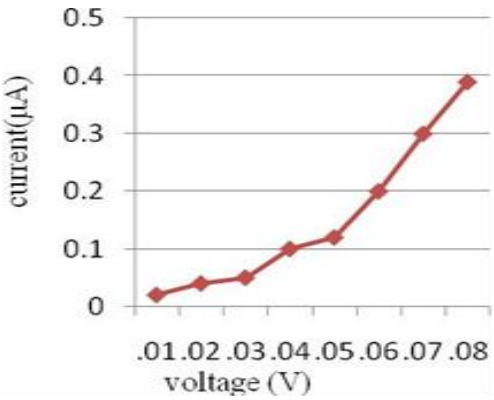

Fig 1: V-I graph of PVDF material

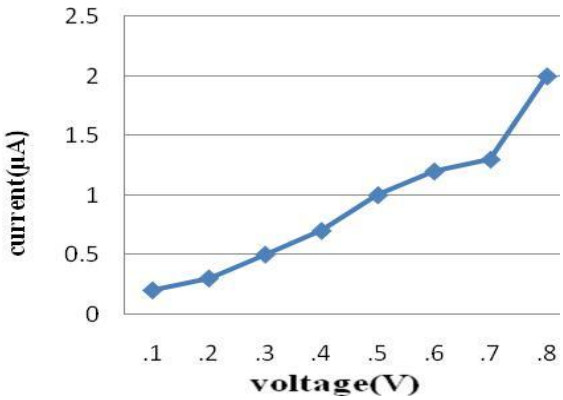

Fig 2: V-I graph of PZT

The voltage from PZT is around 2 V where as that of PVDF is around 0.4V.We can thus conclude that better output is obtained from the PZT than the PVDF.

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 3 and 4.

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Fig .3: PZT in series connection

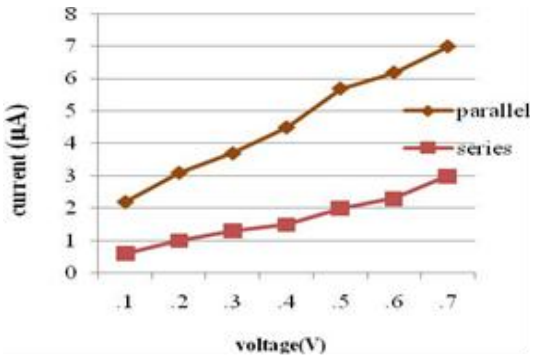

Fig 4: V-I graph of parallel and series connection

It can be seen from the graph that the voltage from a series connection is good but the current obtained is poor, whereas 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.

III. HARDWARE IMPLEMENTATION

The hardware set up is as shown in figure 5. A tile made from piezo material is made. The voltage generated across a piezo tile is supplied to a battery for it to recharge and supply the dc loads. Voltage generated is also givento an inverter, from where it is supplied to all the ac loads.

DESIGN-fig.5 shows the circuit diagram and fig.6 is the hardware model of the project. The major obstacle in designing your own piezoelectric circuit is finding a way to maximize the power output. The major components involved in this circuit would be an AC/DC rectifier, a filter capacitor, and a DC-DC converter. The AC/DC rectifier converts the AC signal from the piezo-source into DC current. The filter capacitor soothes electrical flow and the DC-DC converter is what allows the battery to store the energy. Most of the power conversion comes into play in the DC-DC converter.

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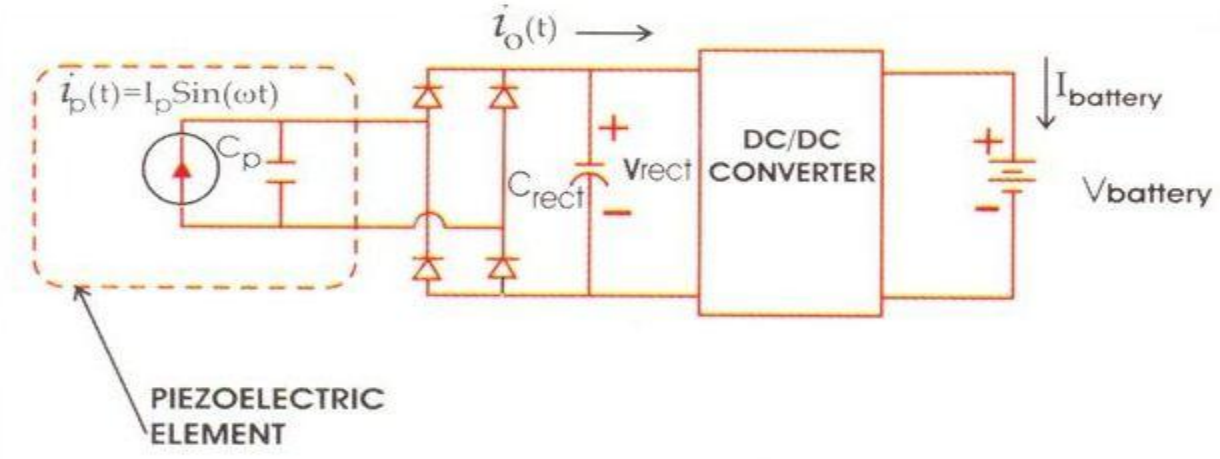
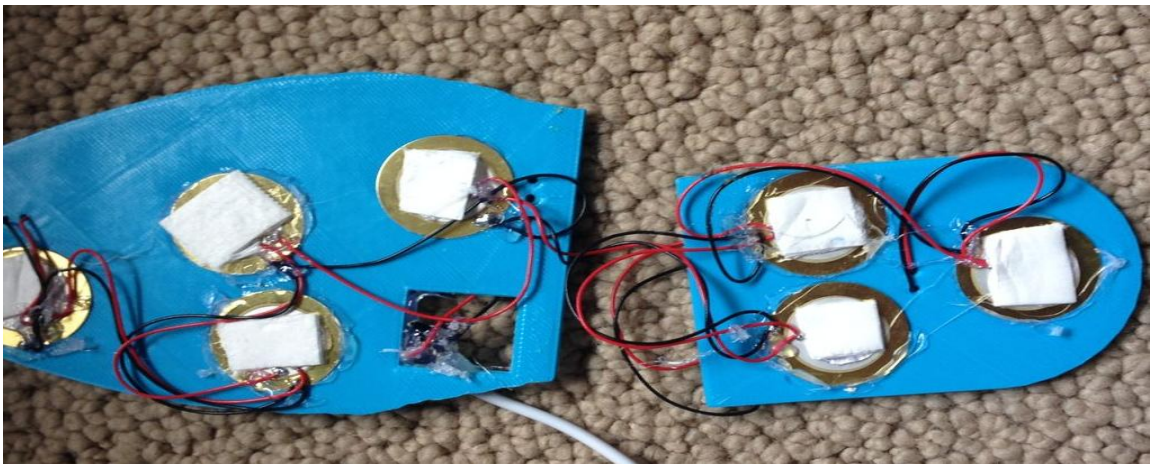


Fig 5: Circuit Diagram

Fig 6: Hardware model



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,

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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 piezo-film 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.

IV. MAXIMUM THEORETICAL VOLTAGE GENERATED

When a force is applied on piezo material, a charge is generated across it. Thus, it can be assumed to be an ideal capacitor. Thus, all equations governing capacitors can be applied to it. In this project, on one tile, we connect 3 piezo in series.10 such series connections are connected in parallel. Thus when 3 piezoelectric discs are connected in series, its equivalent capacitance becomes:

We know, $\frac{1}{Ceq} = \frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3}$

So, $Q = C * V$

Hence, $C = \frac{Q}{V}$

Thus, $\frac{Veq}{Q} = \frac{V1}{Q} + \frac{V2}{Q} + \frac{V3}{Q}$

$$Veq = V1 + V2 + V3$$

Hence, the net voltage generated in series connection is the sum of individual voltages generated across each piezoelectric disc. Output voltage from 1 piezo disc is 13V.

Thus, $Veq = V1 + V2 + V3$

$=13+13+13$

$=39V$

Thus the maximum voltage that can be generated across the piezo tile is around 39V.

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VI.ANALYSIS DONE ON THE PIEZO TILE

Fig.7 shows theSchematicrepresentation of the working modelPeople 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 shown in fig.7. 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.

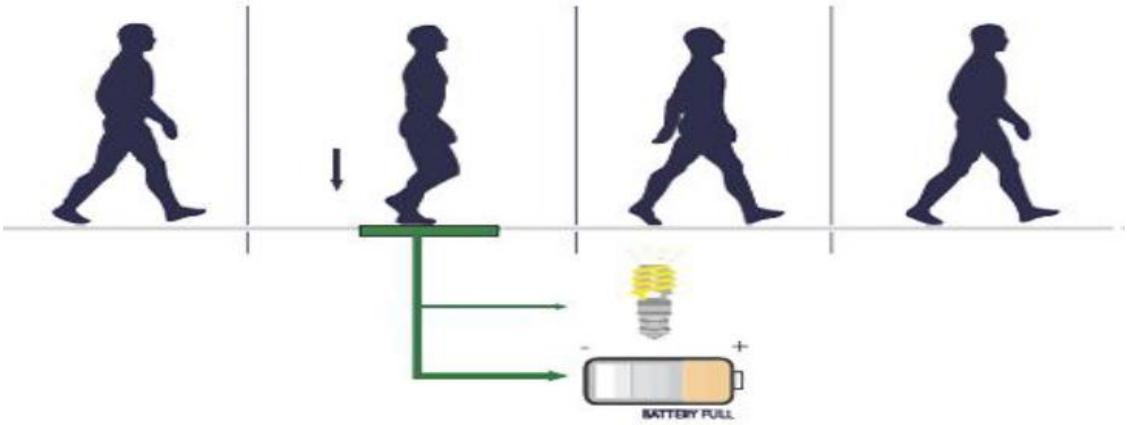

Fig 7: Schematic representation of the working model

VII. CONCLUSION

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 of pavement side buildings.

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