POWER TREAD
Foot Step Power Generation

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Abstract : Since the electrical energy usage has increased we need to find ways to produce electricity using environmental friendly ways; one of which is using human locomotion as a source of energy production. Power tread (formerly known as foot step energy generation system) uses potential energy of footsteps and coverts them into electrical energy using piezoelectric transducers. This is a non-conventional energy source and environment savvy. There are mainly two types of piezoelectric materials namely PZT and PVDF. They can be put in the places where there is good footfall and help us to produce humongous amount of energy around the world.

***IndexTerms*- Footsteps, Piezoelectric, non-conventional, PZT, PVDF**

I. INTRODUCTION

Electricity, which now is becoming a basic necessity, is required in a humongous amount to fulfill the needs of populace. Also we need a non-conventional source of energy since the conventional sources are depleting with each passing day and they produce a lot of pollution, which is one of the major concerns of the decade. On an average we take about 1500-2000 steps per day and only if these steps could be converted into power we can produce enormous amount of electricity. Piezoelectric transducers, a device which converts pressure into electrical signals, can be a breakthrough in terms of power generation through footsteps.

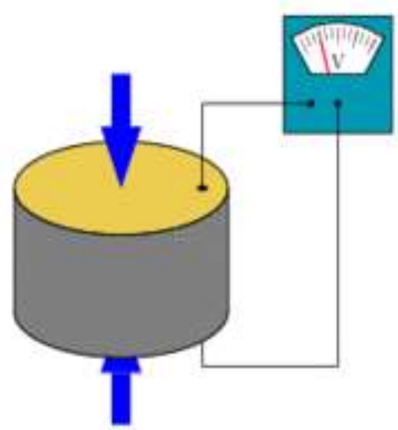

Figure 1 Basic principle of Piezoelectric Material

II. BRIEF HISTORY OF PIEZOELECTRIC MATERIALS

Jacques and Pierre Curie brothers in 1880 demonstrated the piezoelectric effect for the first time. Some of the crystals they used were tourmaline, quartz, cane sugar, topaz and Rochelle salt. Quartz and Rochelle salt were found to be the most piezoelectric. First application of a piezoelectric material was sonar, which was built during First World War. An ultrasonic submarine detector was developed in France in 1917 by Paul Langevin and his coworkers. United States, Russia and Japan, during World War Two, discovered synthetic materials called ferroelectrics, exhibiting greater amount of piezoelectricity than natural crystals.

III. STUDY OF PIEZOELECTRIC MATERIALS

Most common crystals in which piezoelectricity can be seen are piezo-ceramics like PbTiO3, PbZrO3, PVDF and PZT. Choice of right piezoelectric crystal is of utmost importance. To analyze the piezoelectricity we used two most common types of crystals namely PVDF (Polyvinylidene Fluoride) and PZT (Lead Zirconate Titanate). To know the most suitable (of the two) crystals; for the project V-

I graphs of these crystals were plotted. From fig. 2 and fig. 3 (below) we can clearly see that PZT is much better than PVDF since it produces more acceptable output. Where PZT is capable of producing about 2 volts, PVDF can produce only about 0.4 volts under similar circumstances. So, for further research only PZT type of material is used.

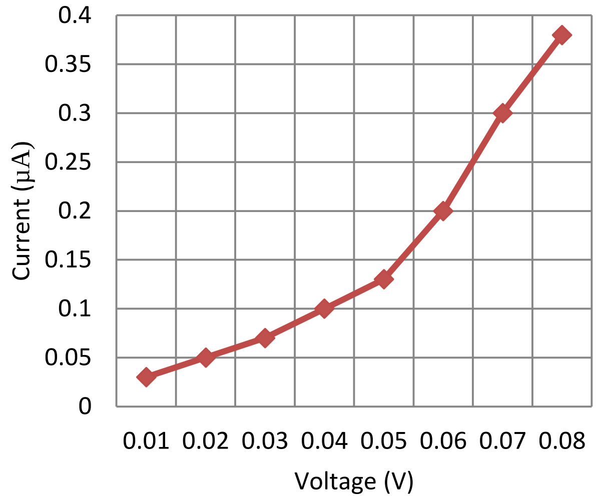

Figure 2 PVDF V-I Characteristics

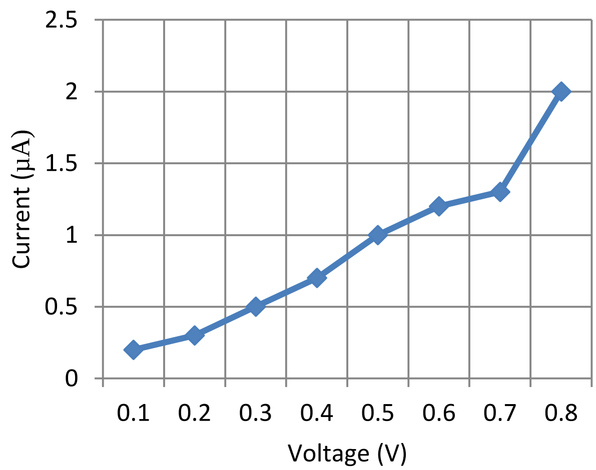

Figure 3 PZT V-I Characteristics

IV. Relation Between Pressure Applied And Power output

The power generated by a piezoelectric crystal is directly proportional to the weight applied on it or in other terms we can say pressure applied on it. As the weight of the body increases the output power observed increases linearly as well, which we can see in the graph given below, Fig. 4. Therefore, heavier the person is greater is the output.

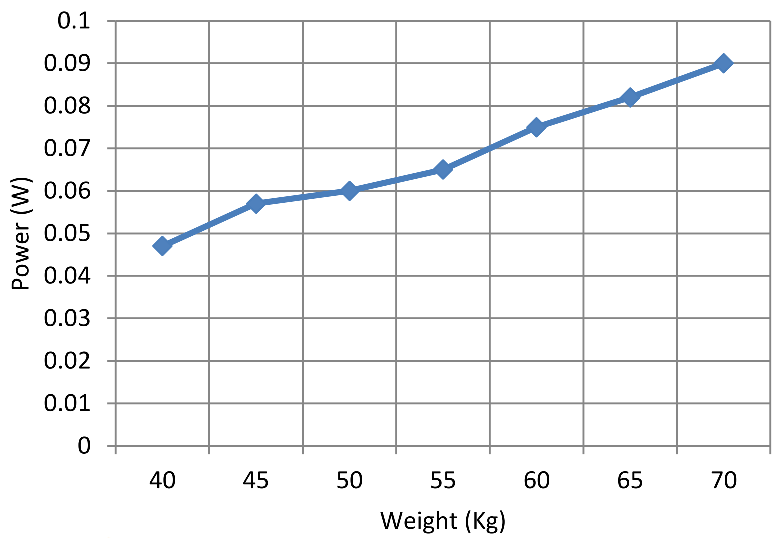

Figure 4 Weight-Power Curve

V. CONNECTIONS EMPLOYED FOR OPTIMUM OUTPUT

Since we need the best possible output so that we can charge our batteries best connections to be made were series-parallel connections. A series connection of two or more crystals improves its overall potential difference measured while a parallel connection is employed to improve its current output. Hence the best result is observed when we connect the crystals in series-parallel connections. Fig. 5 shows the results so observed while connecting the materials in series and parallel connections respectively.

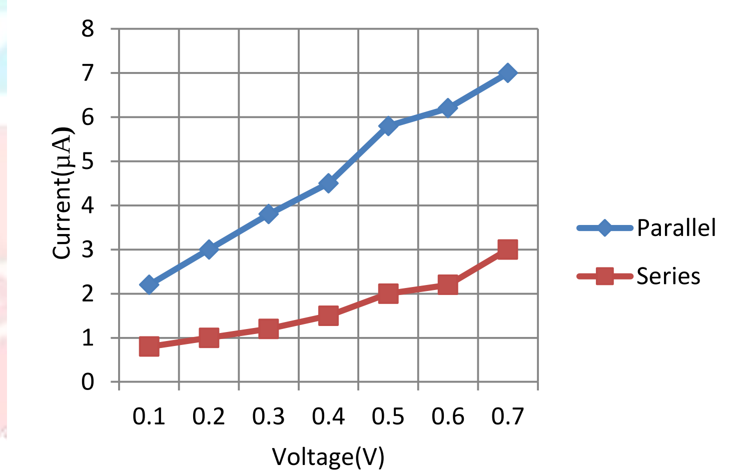

Figure 4 V-I Graph of Series and Parallel Connection

VI. THEORETICAL MAXIMUM VOLTAGE GENERATED

A piezoelectric material can be treated as a capacitor and all the equations relating to a capacitor can be used for the calculations. Let us take an example in which we connect three piezoelectric materials in series and five such series connections are done in parallel. Then the theoretical calculations for the series connections are as follows-

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$Q = C * V$$

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

$$\frac{V_{eq}}{Q} = \frac{V_1}{Q} + \frac{V_2}{Q} + \frac{V_3}{Q}$$

$$V_{eq} = V_1 + V_2 + V_3$$

Output from single crystal is 4.5 volts. Therefore:

$$V_{eq} = V_1 + V_2 + V_3$$

$$V_{eq} = 4.5 + 4.5 + 4.5$$

$$\mathrm{V_{eq}} = 13.5 \text{ Volts}$$

We can generate about 13.5 volts every time we step.

VII. Hardware Implementation And Working

To realize this project we need to place piezoelectric crystals above or below a surface and connect them in suitable series-parallel connections. Placing these materials below a surface needs to be done carefully since the pressure of surface can reduce the output on external application of pressure. To remove this problem a suction cup can be used below each piezoelectric crystal or they can be placed above the surface; a light material, like carpet, can be used to cover the setup.

For the crystals, they are covered with rubber from both sides (as seen in Fig. 5) so as to save them from breaking and rubber also augments to the effect of pressure. This whole arrangement is connected to a battery with a bridge rectifier. The output produced with a piezoelectric crystal is alternating in nature. To convert this AC into pulsating DC suitable to charge a battery we use bridge rectifier. If the load is DC in nature we can directly connect the load to the battery or else we can employee an inverter circuit to supply to AC loads.

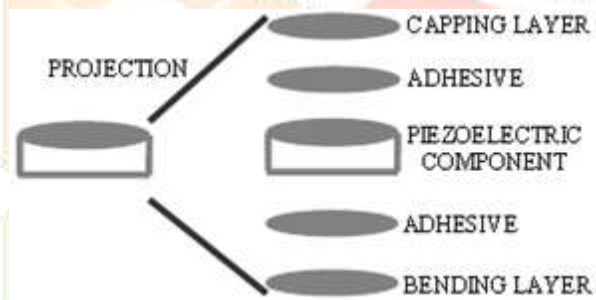

Figure 5 Basic Structure of Single Component

VIII. Potential Applications

In general, this arrangement is very fruitful at the places where there is good footfall and/or places where we observe constant pressure being applied, like keypads.

8.1 Flooring Tiles and Roadside

One of the best applications of these materials is to use them under flooring tiles or at footpaths. Flooring tiles of malls and footpath observe large number of passersby. After storing the power, so obtained, in batteries these can be helpful in powering street lights of road or light loads in mall. It can be truly efficacious to use this technology in malls or at roadsides since there is no time when people cannot be seen walking there.

8.2 Piezoelectric Roads

Under the layer of asphalt a layer of piezoelectric crystals could be laid. When any vehicle passes it exerts pressure on the crystals resulting into generation of power. The obtained power can be used to power street lights or vehicles that run on batteries. Small stations can be constructed from where people can utilize the generated power to charge their electric vehicles.

8.3 Inside Footwear Heels

We exert utmost pressure on our footwear heels. If installed with a small battery and piezoelectric material this arrangement can produce power so as to charge our mobile phones. A small port attached to the arrangement can help us connect the phone with the footwear and it will start to charge.

8.4 Nanotechnology

Small crystals can be installed at malls to power sensors that require power in microwatts. Also small piezoelectric crystals can be used to make piezoelectric ignitors where when beat with a stick the crystal produces a spark so as to ignite the fuel.

IX. Conclusions

Piezoelectric materials are ferroelectric materials that are polar without application of any electric field. These materials can produce power when force is applied. There are many types of natural and synthetic piezoelectric crystals most common of which are PZT and PVDF. With the VI curves we get to know that PZT are better than PVDF materials as they produce more appreciable output. Pressure and output power of materials are linearly related. With the increase in pressure/ weight the generated power increases linearly. The most optimum connection is series-parallel connection as it produces better current and voltage profiles as compared to single material. Maximum voltage that can be generated with this arrangement is 13.5 volts. It is useful at the places where the pressure is applied on regular basis like flooring tiles, roadside, footwear heels and keypads.

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