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Electric Power Generation Using Piezoelectric Materials

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Abstract - The consumption of energy has always been in exponential growth and also there is always an increasing demand in the requirement of energy in some way or the other. So, there is a need to search for energy availability from alternate sources of energy. The utilization of waste energy of piezoelectric power with human locomotion is 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 piezoelectric 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. This research describes the use of piezoelectric materials to harvest energy from people walking vibration for generating and accumulating energy. This study also studies the perceptions and adaptability of piezoelectricity. The adaptability of piezoelectric technology in a real-time environment has been studied by comparing the overall cost of generating electricity with solar energy. This study also suggests a footstep of the piezoelectric energy harvesting model which is cost-effective and easy to implement.

1. INTRODUCTION

To design a system that generates voltage by the human footsteps force. Using non-conventional sources and stores it for usage. The system will have piezoelectric sensors that will convert the measurements of acceleration, force and pressure into electrical signals. It will fully depend on the human footsteps Pressure and convert it into useful power.

I. Project Definition

To design a system that generates voltage by the human footsteps force. Using non-conventional sources and stores it for usage. The system will have piezoelectric sensors that will convert the measurements of acceleration, force and pressure into electrical signals. It will fully depend on the human footsteps Pressure and convert it into useful power. Starting in our project we have two subsystems, the weighting machine and the monitoring circuit. At first by placing the piezoelectric sensors under the weighting machine. So that we can convert them pressure that is applied on the weighting machine into voltage (mechanical to electrical) that will be provided to the microcontroller. The monitoring circuit is based on a microcontroller that allows us to calculate the voltage charge and display it on the LCD display.

II. Project Objectives

Day by day, the population of the country increases and the requirement of the power is also increases. At the same time, the wastage of energy also increases in many ways. So reforming this energy back to usable form is a major concern. As technology is developed and the use of gadgets, electronic devices also increased. Power generation using conservative methods becoming deficient. There is a need arises for a different power generation method. At the same time, the energy is wasted due to human locomotion. To overcome this problem, the energy wastage is converted to usable form using the piezoelectric sensor. This sensor converts the pressure on it to a voltage. By using this energy saving method, foot step power generation system we are generating power. A piezoelectric sensor is a device that uses the piezoelectric effect, to measure changes in pressure, acceleration, temperature, strain, or force by converting them to an electrical charge.

2. PIEZOELECTRICITY

Piezoelectricity, Discovered By Curie Brothers in 1880, Originated From the Greek Word “Piezenin”. The Original Meaning Of The Word “Piezoelectric” Implies “Pressure Electricity’ –The Generation Of Electric Field From Applied Pressure. This Definition Ignores The Fact That The Process Is Reversible, Thus Allowing The Generation Of Mechanical Motion By Applying A Field.

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Piezoelectricity Is Observed If A Stress Is Applied To A Solid, For Example, By Bending Twisting Or Squeezing It. 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.

One of the most suitable methods for obtaining the energy from surrounding system is achieved by using piezoelectric crystals. Piezoelectric crystal is one small scale energy source. When piezoelectric crystals are subjected to vibrations, they generate a very small voltage, commonly known as piezoelectricity. It has crystalline structure that converts an applied vibration into an electrical energy the piezoelectric effect exists in two properties. 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. These properties allow the material to function as a power harvesting medium.

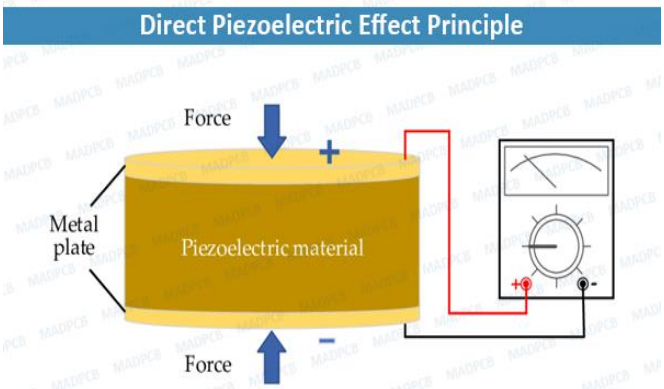

Fig. Piezoelectric Material

PIEZOELECTRIC SENSOR

Piezoelectric sensor is a device that uses the piezoelectric effect to measure pressure, acceleration, strain or force by converting them to an electrical signal. Piezoelectric sensors have proven to be versatile tools for the measurement of various processes. They are used for quality assurance, process control and for research and development in many different industries. It was only in the 1950's that the piezoelectric effect started to be used for industrial sensing applications. Since then, this measuring principle has been increasingly used and can be regarded as a mature technology with an outstanding inherent reliability. It has been successfully used in various applications, such as in medical, aerospace, nuclear instrumentation, and as a pressure sensor in the touch pads of mobile phones. In the automotive industry, piezoelectric elements are used to monitor combustion when developing internal combustion engines. The sensors are either directly mounted into additional holes into the cylinder head or the spark/glow plug is equipped with a built in miniature piezoelectric sensor.

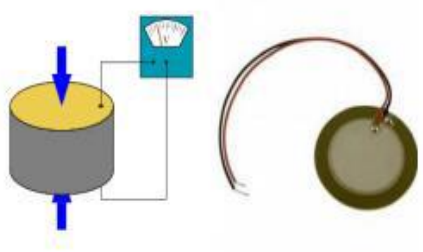

Figure : Piezoelectric sensor

A sensor that utilizes the piezoelectric effect, to measure changes in acceleration, strain, pressure, and force by converting them into electrical charge is called a piezoelectric sensor. This generated piezoelectricity is proportional to the pressure applied to the solid piezoelectric crystal materials.

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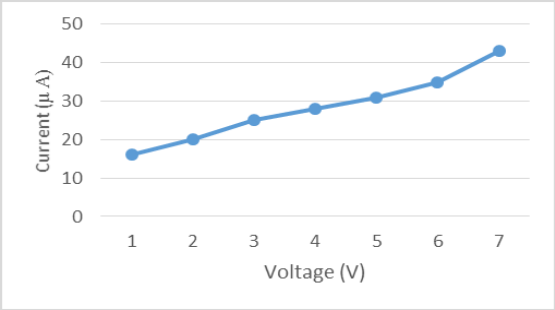

Fig 1. The series connection of piezoelectric transducer

Piezoelements come in handy when you need to detect vibration or a knock. You can use these for tap or knock sensors pretty easily by reading the voltage on the output. They can also be used for a very small audio transducer such as a buzzer. Piezoelectric Sound Disc is a transducer that works on the phenomenon of piezoelectricity i.e. electric charge accumulates in ceramic in response to applied mechanical stress or vice versa. Due to accumulated charge, these plates generate an electric signal which leads to vibration of plates and produces different humming sounds. The frequency of vibration governs the audio that gets produced.

Applications:

Household Appliance Alarms

- Watch Alarms
- Smoke Detectors
- Buzzers and Speakers
- Toys and Games

Connection of Piezoelectric

The piezoelectric transducer was connected in series and parallel connection. Before using the piezoelectric transducer to generate electric energy, the connection needs to be determined to choose the better output from the piezoelectric transducer. Figure 1 shows three piezoelectric transducers were connected in series. Figure 2 shows, three piezoelectric transducers are connected in parallel connection. Two sets of three piezoelectric that connected in series were attached in parallel for series-parallel connection as shown in Figure 3. The multimeter was connected to the piezoelectric transducers to measure the voltage and current across the connection. A double-sided tape 3mm is placed on the top and the bottom of the piezoelectric transducer to maximize the output of this transducer.

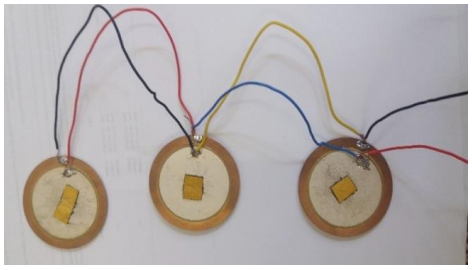

Fig 2. The parallel connection of piezoelectric transducer

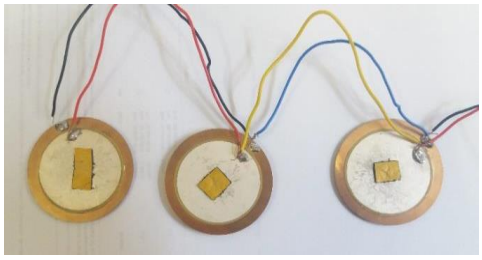

Fig 3. The series- parallel connection of piezoelectric transducer

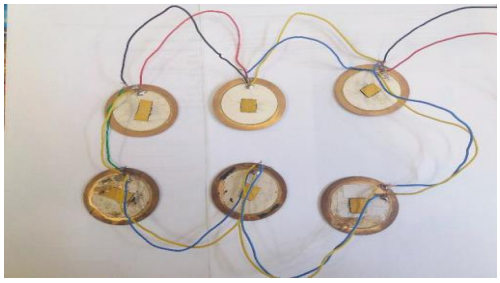

Fig 5 Voltage – Current graph of series-parallel connection of piezoelectric

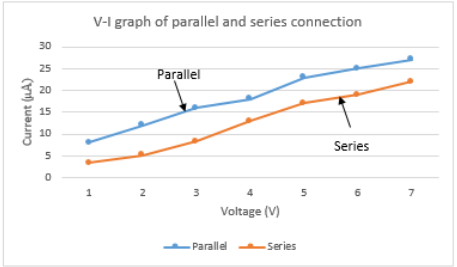

Fig. 4 Voltage – Current graph of parallel and series connection of piezoelectric

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Figure 4 and Figure 5 shows the output of the piezoelectric based on the connection that being done. Figure 4 shows that when the piezoelectric are connected in series the output voltage is high but the output current is low. However, vice versa happened for the parallel connection of the piezoelectric transducer. It gives high current but low output voltage. In order to solve this problem, the combination of this connection needs to carry out. Two set of three piezoelectric transducers that connected in series was attached together in parallel to form series-parallel connection. The values of voltage as well as current output are both satisfactory.

WORKING

The approach we took on this mission is to separate the system into two subsystems.

Product Subsystem 1: Weighing plate and sensors Plate: for the weighing plate we considered Plastic, Glass, Fiber glass, wood. Sensors: We considered the large piezoelectric transducers and the small sized piezoelectric transducers, but we chose the small ones because the large ones are much more expensive and require a lot more mechanical pressure in order to generate very small power.

Product Subsystem 2: Microcontroller:

For the micro controller in our second subsystem we had a few options like Arduino or PIC, and we went with the Arduino due to being more familiar with it and due to its cheap price.

When we integrated our system we simply connected the output of the piezo sensors to a rectifier circuit to convert the voltage to DC and then we fed that voltage into the micro controller in order to display the number of steps and voltage generated across the capacitor. Whenever force is applied on piezoelectric crystals that force is converted to electrical energy which can be used into drive dc loads and that minute voltage which is stored in the battery. Here we are using seven segment displays to show the amount of voltage generated, whenever we place our foot on piezoelectric transducer.

WORKING DIAGRAM

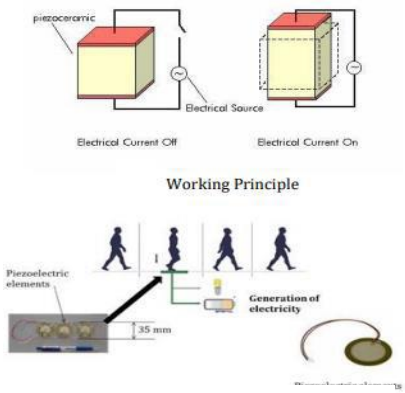

Figure: Working Diagram

3. CONCLUSION

Power generation using foot step is successfully tested and implemented which is the best economical, affordable energy solution to common people. This can be used for many applications in rural areas where power availability is less or totally absence. As India is a developing country where energy management is a big challenge for huge population. By using this we can drive both A.C As well as D.C loads according to the force applied on the piezoelectric sensor.

4. FUTURE SCOPE

In India, maximum public movements is observed in Railways stations and holy places, hence, such places can be Exploited for use of piezoelectric crystals for generation of electricity Gathering ranging from thousands to millions observed in holy places, thus installation of piezoelectric Crystals at floorings would generate enough power to light up Lights of temples as well as air circulation systems. While studying use of piezoelectric crystals embedded in Shoes and roads, idea struck in our mind that piezoelectric Crystals can be replaced with small hydraulic pumps in heels of Shoes and large pumps in case of bridges. While stepping such hydraulic pumps at heel of our shoes would get Compressed and this compressed air can be used to rotate small Electric generators at heel of shoes. Thus, our daily movement can be used to run small electric devices. Though such Generators would be able to generate small power but on large Scale i.e.

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If used in bridge construction than massive energy can Be generated. Similarly by driving on such road & bridge, due To compression the hydraulic pump can to rotate generators in Turn generate electricity.

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