International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE) Volume 1, Issue 2 June 2016

Generation of Electricity by Human Motion Using Piezoelectrics

[1]Gowtham.S
[1] Department of Mechanical engineering,
PES Institute of technology,
Bangalore, India.
[1]gauthamgreat10@gmail.com

Abstract: **In physics, energy is property of objects which is transferred to other objects or converted into different forms. In recent days there is a vast scarcity of energy sources, due to depletion of non –renewable sources of energy. So there is a very high requirement of energy conservation. Also, since there is an urge for energy conservation techniques in recent years, there are many devices which run on non-conventional sources of energy. However, a very unique method of generating electricity is piezoelectricity. Piezoelectricity is the electric charge that accumulates in certain solid materials, in response to applied mechanical stress. . In order to generate electricity, the mechanical pressure is acted upon certain sensors called as piezoelectric sensors. The devices consisting piezoelectric sensors are called as piezoelectric devices. Piezoelectric are materials that generate a voltage when they are subjected to mechanical pressure; conversely, when subjected to an electromagnetic field, they exhibit a change in dimension. . In this concept we propose, generation of electricity by human motion. The idea is to put piezoelectric sensors in the footwear of people so as to produce electricity, during their routine activity of walking, cycling, running, etc. The electricity is produced due to the weight of the person acting on the piezoelectric devices and in turn storing that energy for various other purposes. Also, it is evident from the theory and calculations of piezoelectric devices that it is possible to generate a large amount of electricity in a short period of time. Also, the generated electricity is safe to use and also can be used in the form of batteries to charge small voltage power supply devices. Usage of this footwear for a long period of time will result in generating sufficient amount of electricity for daily needs. Mainly, generation of electricity can be done with routine activity itself, instead of consuming conventional sources of energy.**

***Index Terms*— footwear, piezoelectric devices, power generated, weight.**

I. INTRODUCTION

In physics, energy is property of objects which is transferred to other objects or converted into different forms.[1] In recent days there is a vast scarcity of energy sources, due to depletion of non –renewable sources of energy. So there is a very high requirement of energy conservation .So, Energy conservation is reducing energy consumption through using less of an energy service. Energy conservation differs from efficient energy use, which refers to using less energy for a constant service.[2]

Even though energy conservation reduces energy services, it can result in increased environmental quality, national security, personal financial security and higher savings.[3] Since there is an urge for energy conservation techniques in recent years, there are many devices which run on non-conventional sources of energy. However, a very unique method of generating electricity is piezoelectricity. Piezoelectricity is the electric charge that accumulates in certain solid materials, in response to applied mechanical stress. [4]

The piezoelectric effect is understood as the linear electromechanical interaction between the mechanical and the electrical state in crystalline materials with no inversion symmetry.[5] Piezoelectricity is found in useful applications, such as the production and detection of sound, generation of high voltages, electronic frequency generation, to drive an ultrasonic nozzle, and ultrafine focusing of optical assemblies. In order to generate electricity, the mechanical pressure is acted upon certain sensors called as piezoelectric sensors.

The devices consisting piezoelectric sensors are called as piezoelectric devices. Piezoelectrics are materials that generate a voltage when they are subjected to mechanical pressure; conversely, when subjected to an electromagnetic field, they exhibit a change in dimension. Many piezoelectric devices are made of the same ceramic materials as capacitor dielectrics.

Piezoelectric devices work on the phenomenon of piezoelectric effect. Piezoelectric Effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress. One of the most important characteristic of piezoelectric devices are that they are reversible. By reversible it means that they exhibit direct or normal piezoelectric effect and also the converse

piezoelectric effect.

In this concept we propose, generation of electricity by human motion. The idea is to put piezoelectric sensors in the footwear of people so as to produce electricity, during their routine activity of walking, cycling, running, etc. The electricity is produced due to the weight of the person acting on the piezoelectric devices and in turn storing that energy for various other purposes.

II. MATERIAL SPECIFICATIONS

A. *Piezoelectric material specifications*

For the generation of electricity, the piezoelectric materials used has been the commonly used one. It has got a diameter of 15cms and thickness 3 mm. The capacitance of this piezoelectric crystal is 2.08nF. Also, the value of load proportionality constant is 598 C/N.

The voltage supplied across the piezoelectric crystal is 121.644V. Also, we know the ratio of capacitance of the piezoelectric crystal to the energy stored by cycle per unit time is $7.5x10^{-9}$.

To calculate the area of the piezoelectric crystal,

d = 15 cms

Area = $(3.14 \times d^2)/4$

= $(3.14 \times 15^2)/4$

= $176.71mm^2$.

B. *Weight and size of footwear specifications*

The average weight of a person around the world is 62Kg.[6] Since calculations are involved in Newtons,

W= M x g

= 62 x 9.81

= 608.22N.

Also the average footsize in the world is around 9 inches. To take precise values for calculations,

L = 26.2 cms

B= 9.906 cms

Therefore,

Total area = L x B

= 26.2 x 9.906

= $259.54cms^2$.

= $25953.72 mm^2$.

III. CALCULATIONS

To calculate the power developed by the piezoelectric device,

P = (C_{Piezo} x V^2) /(2 x energy stored by cycle)

Where,

P is the power developed

C_{Piezo} is the capacitance of the piezoelectric device

V is the voltage supplied

= $(7.5x10^{-9} \times 121.144^2)/2$

= $5.54x10^{-5}$ W.

Since this involves calculation for one piezoelectric device, the number of such devices can be obtained by,

Number of devices that can be fit to footwear = (Area of the footwear)/ (Area of the piezoelectric device)

= 25953.72/176.71

= 146.87.

According to the calculations, the number of devices that can be fitted is 146.87. Since at the corners of the foot wears, it is impossible to fit the piezoelectric crystals, we consider the number to be 130 at the lowest possible minimum condition.

Therefore the total power developed for 130 crystals,

Total power = 130 x $5.54x10^{-5}$W

= $7.202x10^{-3}$ W.

Since this is the total power developed by the unit per cycle,

The total power developed per minute,

= $7.202x10^{-3}$ W x 0.378 x 60

= 0.1633 W.

PRACTICAL USAGE

Consider the necessity to be lighting a 60W bulb for an hour,

Then,

Time required = (number of watts required per min)/ (number of watts developed per min)

= 1/ (0.1633)

= 6.12 mins.

This value of 6.12 mins is obtained only theoretically. In practical conditions, since it is not possible to obtain ideal conditions due to non- constant loading and external factors like air resistance, friction, etc, the practical value would be around 15- 20 mins.

Thus, for lighting a 60 W bulb, it would take around 15-20 mins in the piezoelectric footwear to generate the equivalent amount of electricity.

IV. ADVANTAGES

A. Generation of electricity can be done with routine activity itself, instead of consuming conventional sources of energy.
B. Also, the generated electricity is safe to use and also can be used in the form of batteries to charge small voltage power supply devices.
C. It serves as an alternate source of energy supply rather than consuming the already diminishing non- renewable sources of energy.
D. Usage of this footwear for a long period of time will result in generating sufficient amount of electricity for daily needs.

V. CONCLUSION

In this conceptual project, we can thus produce electricity from human motion, including routine activities such as walking, jogging, running, etc. Also, we saw from the above calculations that for a short period of time, we can generate a large amount of electricity from the specified conditions. Thus, by adopting this method of generating electricity, we can reduce the usage of conventional sources of energy, which are in diminished quantities in the present generation.

REFERENCES

[1] Kittel, Charles; Kroemer, Herbert (1980-01-15). Thermal Physics. Macmillan. ISBN 9780716710882.

[2] "Energy conservation vs. energy efficiency". Natural Resources Canada. Retrieved May 13, 2014.

[3] "Unintended Consequences of Green Technologies". University of California, Berkeley. Retrieved 26 December 2012.

[4] Holler, F. James; Skoog, Douglas A; Crouch, Stanley R (2007). "Chapter 1". Principles of Instrumental Analysis (6th ed.). Cengage Learning. p. 9. ISBN 978-0-495-01201-6.

[5] Gautschi, G (2002). Piezoelectric Sensorics: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors, Material.Amplifiers.Springer. doi:10.1007/978-3-662-04732-3.ISBN 978-3-662-04732-3.

[6] Walpole, Sarah C; Prieto-Merino, David; Edwards, Phil; Cleland, John; Stevens, Gretchen; Roberts, Ian; et al. (18 June 2012). "The weight of nations: an estimation of adult human biomass". BMC Public Health (BMC Public Health 2012, 12:439) 12 (1):439,doi:10.1.1186/1471-2458-12-439.PMC 3408371.PMID 2 2709383.