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Design Concept of Power Stockings

Arindam Ghosal[1*], Pravin P. Patil[2], Nitesh Rawat[3], Gaurav Gusain[4]

[1,2] Department of Mechanical Engineering
[3]Department of Computer Science and Engineering
[4]Department of Electronics Engineering
Graphic Era Deemed to be University, Dehradun, India
*Corresponding author: er_ghosal@yahoo.co.in

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Abstract
This paper presents the experimental design concept of an energy harvesting system that uses the mechanical energy of our body to generate and store electricity for further use. It uses active elements to generate electricity from the base of our stockings, it uses piezoelectric elements. While walking there it will be the mechanical stress in piezo element, when this stress is released then there would be the production of the electric charge which will be harvested in the flexible battery attached to the stocking. The electric energy processing will be maintained by using energy harvesting module.

Keywords-Piezoelectric Elements, Energy Harvesting, Mechanical Energy, Flexible Battery, Stockings.

1. Introduction

The world is getting high tech and we are in the extreme age of technology but still there are some regions in our scientific world where we are lagging behind. One of such problem is with the generation of energy for survival purpose.

At present, electricity has become a lifeline for human population. Now a day we are more advanced in our technical world so it is hard to get into any problem but if we do get in any problem than we have a variety of survival kits, but still we don't have any gadget to add electricity generator in it. If electricity would be added to our survival kits, then it is quite easy to reduce our effort and surely it will increase the chances of survival. Power stocking does this effectively.

When somebody will have stuck in the worse conditions like earthquake and floods when power cut off takes place, then with the use of power stocking the individual can generate electricity.

Studied from the website it is understood that annual surveys in 2010, deaths by earthquakes are 62378, by epidemics 4000 and by floods 6992. It uses just simple walking process to produce electricity and stores it in the battery it has. It's a device which will be simply worn as a stocking and then on walking or running it'll generate electricity which will be stored in the thin flexible lithium polymer battery present in the stocking, which can be used for several purposes like for producing fire, sending SOS messages, etc.

This design is based on a principle called the piezoelectric effect, under which we can say that certain materials have a capability of converting the mechanical stress energy applied on them into electrical energy (Boby et al., 2014). Till now the pressure energy produced by human body is wasted, but by using some energy harvesting elements in our wearable, we can harvest this pressure or strain energy into any other form for the future references. So, based on this principle we have designed power stockings which can be used to convert pressure energy produced by human body into electrical energy as shown in Figure 1.

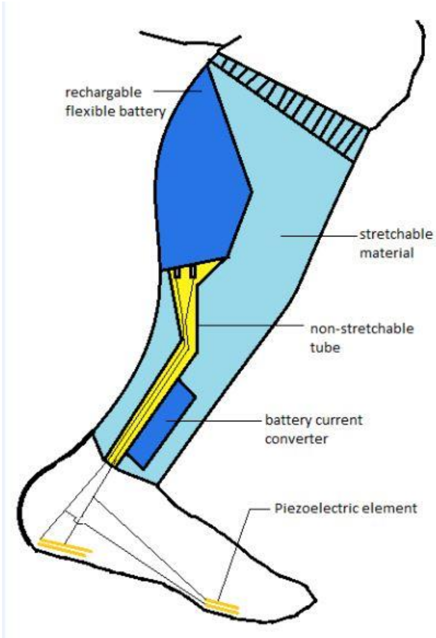

Figure 1. Design of power stocking

2. Working

This design works on the principle of piezoelectricity, which tells that the stress energy on any piezo element can be converted into electric energy. The flow chart of the whole working process is given in Figure 2. First the stress caused by walking will be stored.

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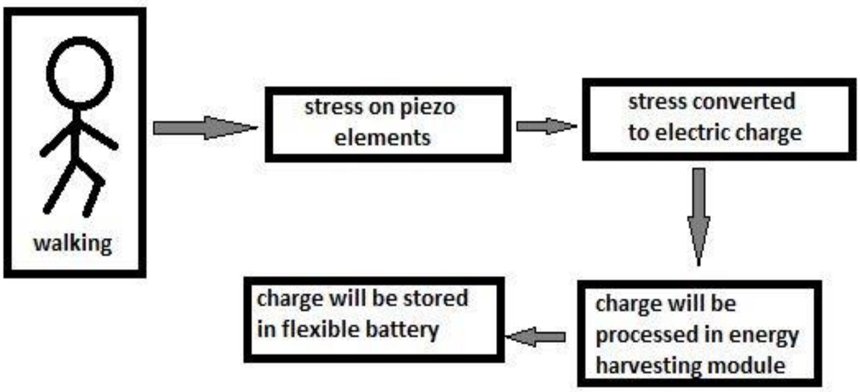

Figure 2. Flow chart of whole working process

The piezo element and then when it is released, it will generate electric charge, which will be processed by energy harvesting module and then will be stored in the battery present in the stocking. Then a port is connected to the battery from which we can charge our equipment.

To explain the direct effect and the reverse effect, the following modeling is done
Direct Piezoelectric Effect: $D = d. T + \varepsilon^T. E.$
Converse Piezoelectric Effect: $S = s^E.T + D_t. E.$

Where, D is the electric displacement vector, T is the stress vector, ε^T is the dielectric permittivity matrix at constant mechanical stress, s^E 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, 't' stands for transposition of a matrix. There are two coupling modes for piezoelectric energy generators, these modes are understood by the direction of the mechanical force subjected on piezoelectric crystal and electric charge collected on electrodes. The direction of polarization is conventionally denoted as the direction 3. As shown in Figure 3 the 3-3 mode implies that charges are collected on the electrode surface perpendicular to the polarization direction when compressive forces are applied along the polarization axis.

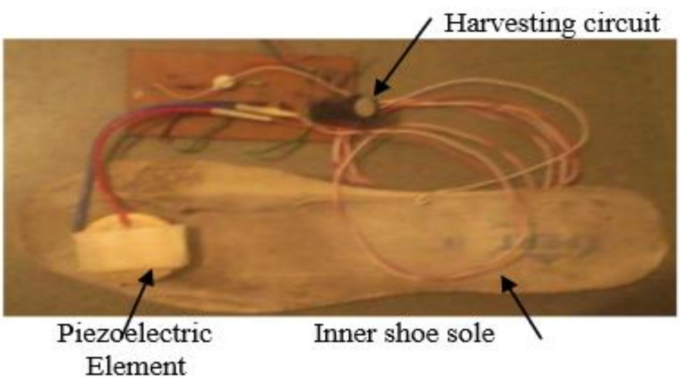

Figure 3. Piezo energy harvesting via shoe sole and

3. Terminology

Stocking: Stocking implies to a simple sports socks which covers your whole leg part that is below knee.

Flexible battery: A flexible battery is a device to store electrical charge in it and will be up to 170 microns thin which makes it suitable to be fitted in a stocking.

Piezoelectricity: Piezoelectricity is the electricity formed by the conversion of the pressure energy into the electric energy by the use of any suitable material.

Piezoelectric element: A piezoelectric element is a device which has two metallic plates and between these two plates there lies a special material which on release of any strain provides electric sensation.

Energy harvesting module (battery current converter): Energy harvesting module is a device which converts the piezo current to the form which can be stored by the battery easily without any hindrance.

Non-stretchable tube: It is a capillary to save connecting wires from any threat; they will have less elasticity than the other parts.

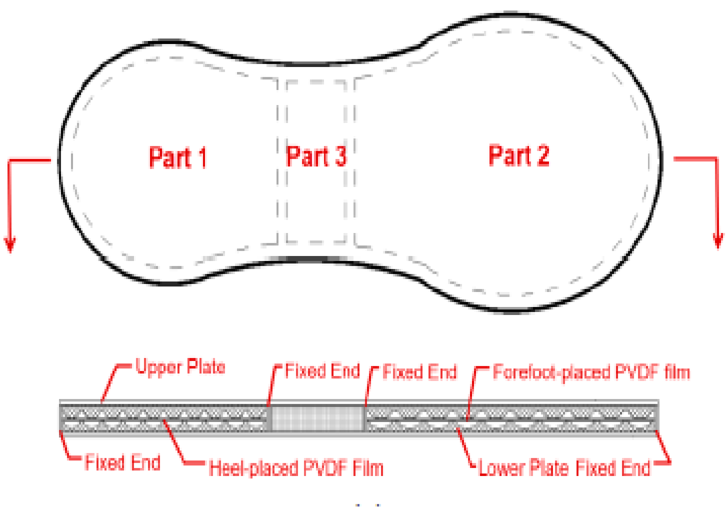

Figure 4. Shoe embeded energy harvest

4. Literature Survey

Piezoelectric Energy Harvesting via Shoe Sole (Gupta and Sharma, 2015):

According this paper, generation of electricity with the same principle as of power stockings, it converts pressure energy to electrical energy by piezo elements. Though this project is successful in generating electric current through piezo electric cell but the main drawbacks of this project are:

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The setup shown in Figure 4 is large due to the circuit board and there are more chances of breaking the circuits than our project.

As the whole circuit is fitted inside the shoes therefore we have to take a good care of these shoes as these shoes have to go through many climatic and physical conditions at any place so there are more chances of breaking of shoes which increase the chances of breaking or damaging the shoes and then this whole setup is of no use. On the other hand, in our project the piezoelectric cells are fitted

Inside socks which we can wear with any shoes and we only have to take care of socks and there are fewer chances of socks getting damaged than shoes.

Our project is easily portable as socks do not take a large space but the piezoelectric shoes take a large space which make it little difficult to carry when not wearing them.

A Shoe-Embedded Piezoelectric Energy Harvester for Wearable Sensors (Zhao and You 2014). In this project also there are some drawbacks, they are as follows:

The setup shown in Figure 5 is large due to the circuit board and there are more chances of breaking the circuits than our project.

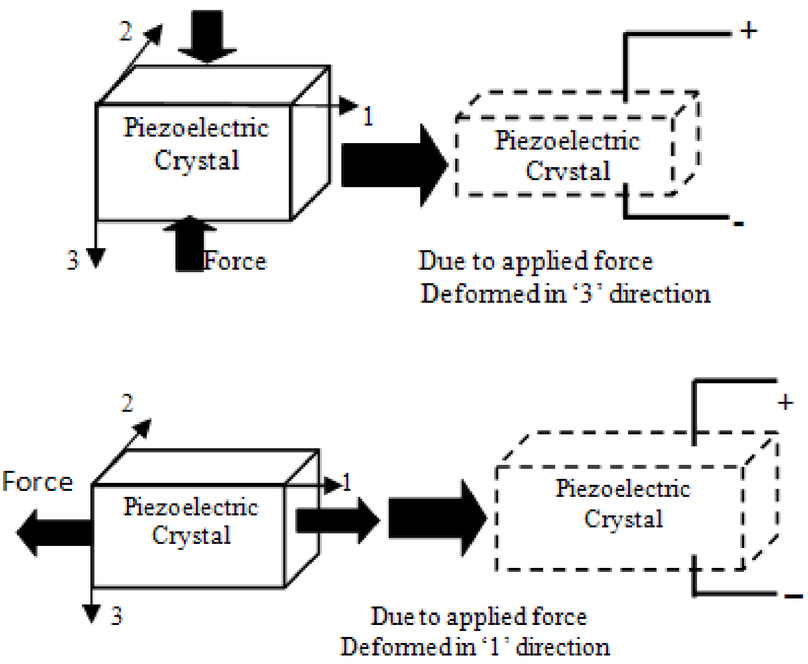

Figure 5. Set up

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As the whole circuit is fitted inside the shoes therefore we have to take a good care of these shoes as these shoes have to go through many climatic and physical conditions at any place so there are more chances of breaking of shoes which increases the chance of breaking or damaging of shoes and then this whole setup is of no use.

On the other hand, in our project the piezoelectric cells are fitted inside socks which can be worn with any shoes and we only have to take care of socks and there are less chances of damaging of socks than shoes. Our project is easily portable as socks do not take a large space but the piezoelectric shoes take a large space which make it little difficult to carry while not wearing it.

Piezoelectric micro power generator for energy harvesting is a thin film of Lead Zirconate-Titanate power.

It uses vibration to generate electricity (Sood et. al, 2004) and the construction of this device is shown in Figure 6.

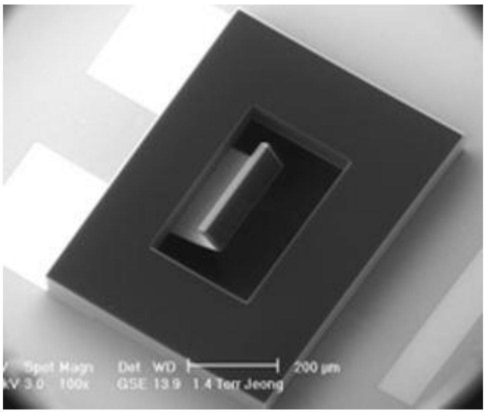

Figure 6. Piezo electric micro power generator

The only disadvantage is that when the device subjected to high vibration for which it is not wearable.
Device needs high vibration rate hence less field of application.

5. Results

The experimental data obtained is shown in the Table 1. It tells us about the average voltage generated by applying a variety of weights on piezo elements.

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Table 1. Experimental data table

Weight applied	Volts generated	Avg. volts applied
5.32 Kg	5.01 V	
4.17 Kg	5.26 V	
4.53 Kg	3.79 V	4.766 V
5.12 Kg	5.54 V	
4.06 Kg	4.23 V	

Average weight applied 4.64 Kg.

Diameter of piezo element used=25 mm.
Average weight applied=4.64 kg.
Average volts generated=4.766 volts.

6. Conclusion

The older devices don't have any flexibility in them and hence can't be taken anywhere easily; power stockings are all about improving the quality by adding the flexibility in piezoelectric generator and adding its application in the field of survival devices. It can increase the chances of survival in case of any mishap like earthquake, floods, etc.

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Links

Annual global no. of deaths from natural catastrophe per decade, 1900-2013;
https://ourworldindata.org/natural-catastrophes/