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FOOTSTEP POWER GENERATION AND PERFORMANCE ANALYSIS THROUGH DIFFERENT TYPES OF FOOTWEAR STYLES

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Abstract- *In modern era electricity becomes one of the most necessary things in human life. To do our daily life work we need electric power. As the population is increased the demand for electric power also increased. We can generate electric power through various processes but all the process is not cost-effective and eco-friendly. On the other hand, the natural sources like gas, fuel, coal are decreasing day by day to fulfill the demand of electric power. Therefore besides conventional process we need to think the way of generating electric power by non-conventional way. Power generation by footstep is a cost effective, waste of energy reduction and eco-friendly method. In this study we focused on power generation using different types of footwear, different portions of our foot by simply running on the road through foot step. The basic principle of our work is based on the piezoelectric sensor. This project using simple drive mechanism such as rack and pinion assemble and chain drive mechanism for the conversion of the force energy in to electrical energy. The study indicated that power generation in order of sport shoe> sandal> Derby shoe> Moccasin > Loafer at different parts of these shoes. Maximum power generation was 3.5 volt by sport shoe. In respect of our foot portion maximum voltage was 1 volt and the portion is heel. The power generation against different parameters e.g pressure, weight, time was studied. our project model is easy to implement. It can be used for charging devices e.g. laptop, mobile, etc*

Keywords: Electric power; Footstep; Force energy; Sport shoe; Heel

1. INTRODUCTION

The population of the world is increasing day by day with that the demand for electricity is also increasing proportionally due to its use in every aspect of daily chores. To fulfil this huge demand, resources are limited [1]. The generation of electricity is done by resources like water [2], wind and other sources which is both costly and cause pollution. To produce the electricity, power plants and factories burn coal, oil, and natural gas by which we do all kinds of things. Due to the burning of fossil fuels, there is more frequent acid rain in every year. [3]. Due to this ozone layer is also destroying which causing global warming, Global warming causes changes in temperature, recent winters, glacier and ice cap melting, sea level rising etc. If the conventional method of producing electricity continues like this then the environment and all living lives will be in terrible danger [4].

It is high time to invent an alternative method of generating electricity which will be both affordable, eco-friendly to common people and fulfil the daily demand for electricity. Recent days experiments in electronic engineering are increased of wearable or portable devices. Mass attention has recently created among researcher to harvest energy due to kinetic motion in the human body during different activities and further convert this energy to electricity. When the human foot strikes the ground, a force produced which is two times the human's body weight [5]. Every day an average person spends maximum time of his/her day on foot and the energy produce while hitting the ground with heel is wasted. If this wasted energy can be used then it can play a vital role to receive the demand for electricity. In recent years many systems developed which successfully recovered energy and transform it into electrical form. This electricity use to run different electronic device which can be operated by a small amount of electricity. These devices can monitor human activity and provide time to time update of the carrier present health condition [6]. Kymissis et.al [7] reported that, for a 68-kg person walking with a speed of 2 steps/S and 5 cm heel movement, 67W is the maximum energy that can be created. The energy extracted from walking will obviously decrease due to the interference with the gait brought by the energy-harvesting devices. In that case with a mechanical power loss of 75%, the electrical power loss of 10%, electromechanical efficiency of 50%, and daily rate of 16.6%, the theoretical limit of piezoelectric energy harvesting are approximated to be 1.265 W [8].

Piezoelectricity effect is the technology where the pressure of human foot which is produced while walking

is used to generate electricity. This energy will be wasted if not utilized properly. With the help of embedded piezoelectric material proper utilization of converting pressure into electric current is done by Piezoelectricity effect [9].

In the current study, an investigation was made to generate electrical power by using human footstep by using a piezoelectric sensor. The performance of the piezoelectric sensor to generate power was assessed by evaluating different parameters: types of footwear and foot portion.

2. MATERIALS AND METHODS

2.1 Materials

Different types of shoe sandal, Derby, Moccasin, Loafer, and sports were purchased from the local footwear shop. For insole PVC materials were used.

Different types of piezoelectric materials (Quartz, Berlinite, Sucrose, Rochelle salt, Topaz, Tourmaline-group minerals) and the component of circuits (Piezo-electric transducer, Diodes, Resistor, Capacitors, LED, Switch) were purchased from a local scientific store, Khulna, Bangladesh.

2.2 Experimental Setup

Initially, the required position was find out for inserting piezoelectric material based on exposed of maximum pressure zone of insole. After that, the zone was isolated as toe, waist and heel portion of insole. Hence, the diameter of the piezoelectric material was measured & seven holes inside the insole were made (fig.1) for inserting piezoelectric materials and bridge rectifier.

Fig.1: Insole hole

Although piezo elements generate plenty of voltage, they do not generate many amps. To solve this problem, the piezoelectric elements were connected to a parallel connection (fig.2). In case of piezoelectric material insertion within the insole material we carried out such an assembling with extra care due to avoid any distortion of piezoelectric material in the insole material. The assembling was like sandwich with insock, insole and soling materials. Our endeavor was concentrated about pressure from walking feet which assists for obtaining maximum energy harvest. This assembling procedure was conducted for different footwear style like loafer, moccasin, derby, sandal and sport shoe as well.

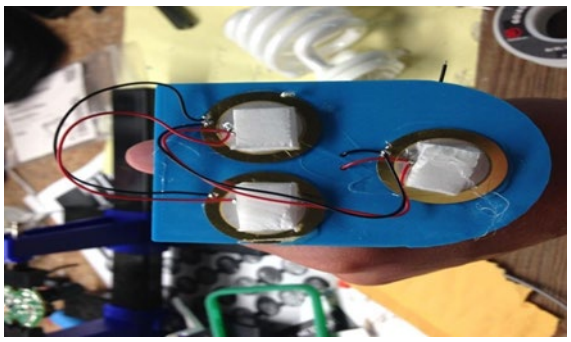

Fig.2: Parallel connection

In order to charge the daily stuff DC current is needed, not AC. So to convert the AC current into DC a rectifier bridge was prepared (fig. 3). The final energy stored in power bank which has USB like port. The data cable of any devices or end product like mobile, laptop and camera etc. to be charged by the using of this port of the energy stored device.

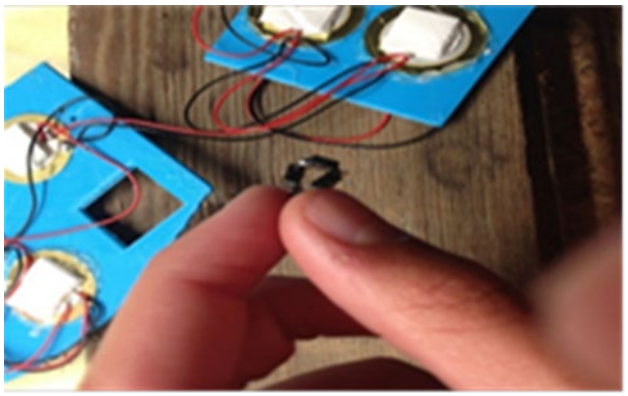

Fig.3: Preparation of Rectifier Bridge

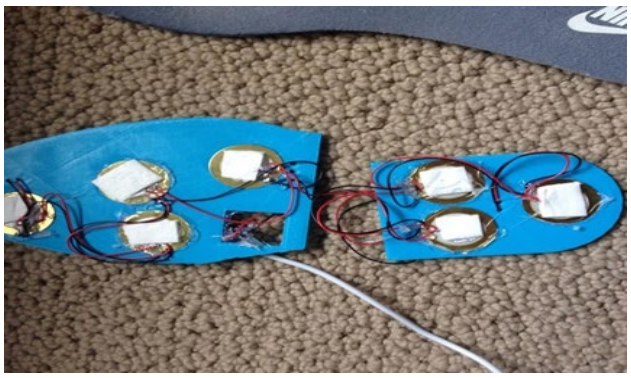

Fig.4: Complete insole with piezoelectric materials

2.3 Insertion of insole containing piezoelectric materials into the shoe

After setting the piezoelectric materials on the insole, the insole was inserted into the shoe as shown in the figure. 5. The insole was inserted on to the top of the original sole then another foaming material was inserted on to the top of the insole.

Fig.5: Insole setting into the shoe

2.4 Working Principle

The insole was engineered with piezoelectric technology; the electrical energy produced by the pressure was captured by insole sensors and converted to an electrical charge by a piezoelectric transducer. These sensors were placed in such a way that it generates the maximum output voltage. During a casual walk when a person or loads press the arrangement, then the upper surface of the iron plate move downwards. When the pressure was applied to the face of the piezoelectric element then it generates the ac voltage and was sent to the rectifier. Then the function of the rectifier was to achieve full-wave rectification. Thus transforming the ac voltage to dc voltage. The rectifier was a bridge circuit made by diodes. The dc voltage was stored in a capacitor in the subsequent stages.

3. RESULTS AND DISCUSSION

3.1 Power generated for different shoe styles

In the batch experiment, power generation was observed for different shoe styles: Loafer, sandal, Sport shoe, Derby, Moccasin. Figure 6 represents the power generation for different shoe styles. For sandal, Derby, Moccasin, Loafer respective power generation was 3V, 2.5V, 2V, 1.5V.

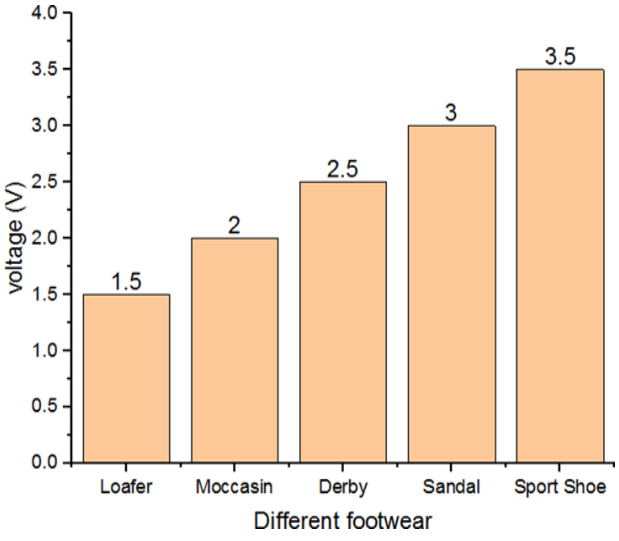

Fig. 6: Power generation at different footwear

Maximum power generation was 3.5 V from sports shoe due to its structure and the way it was used. Normally sports shoe is used to do heavy work like hiking, running [10], playing, balance training [11] to do that type of works high pressure was applied on the insole as well as a piezoelectric transducer and thus power was produced. On the other hand, the lowest amount of power generated from the loafer shoe (1.5V) this could be explained that loafer shoe only uses for party purpose and the minimum amount of pressure imposed onto the insole of loafer shoe compare to a sports shoe.

3.2 Power generation for different portions of footwear

Human body pressure plays a vital role to generate power by human footstep. Due to human foot structure, the pressure applied on the insole is varied portion to portion of the footwear. On average 2.3 MPa pressure is imposed for every 31.2mm^2 area of human foot [12].In normal walking, hell is the 1st portion who stuck the ground first and all the body pressure imposed onto hell [13].

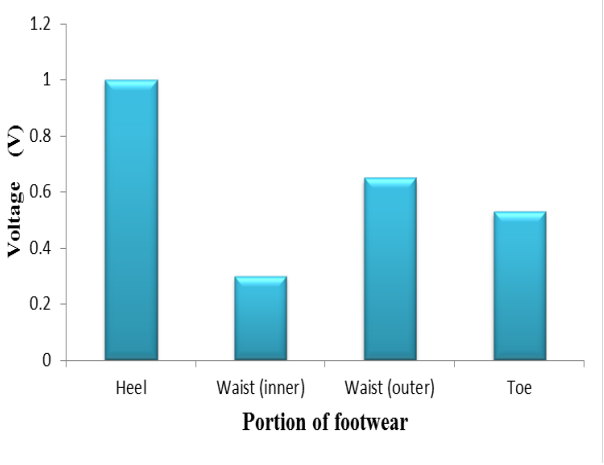

Fig.7: Power generation at different portions of footwear.

From fig.7 it is clear that maximum power generates at the heel portion and it was 1 volt. The lowest amount of power generates at inner waist portion (0.3V) as inner waist portion remain untouched onto the insole during standing as well as walking. So no pressure is imposed onto the piezoelectric material in the inner waist portion. From the inner waist portion, power generation starts to increase to toe portion (fig.7). During walking at first hell receive the body pressure then the pressure distributes to midfoot and forefoot.

3.3 Time calculation for generating voltage

Table 1 represents the output voltage for different types of footwear.

Table 1: Footwear and their output voltage per step

Footwear names	Heel height(cm)	Toe spring(cm)	Output voltage(V)
Sandal	1.5	2	3
Moccasin	1	4	2
Sports	4	2	3.5
Loafer	1	3.5	1.5
Derby	3	4	2.5

In one insole seven piezo elements were used. Power generating a capacity of piezo elements varies with human footsteps. Got minimum voltage of 1.5 V per step for loafer and a maximum voltage of 3.5 V per step for sports shoe (Table 1). Human weight was 50Kg; he took 800 steps to generate 1V charge in a battery.

So to generate a maximum voltage (3.5V) the number of steps needed was:

$$Footsteps = 3.5 \times 800 = 2800$$

The experimental human took 1 second for 2 steps.

$$\text{For 2800 steps time needed} = \frac{2800}{60 \times 2}$$
$$= 23.33 \text{ Minutes}$$

4. CONCLUSION

Power generation using human footstep was an effective technique as it produced a reasonable amount of power. The results of the present work showed that among different types of shoe sport shoe produced maximum power. The weight applied on the insole and corresponding voltage generated is studied and they are found to have linear relation. In our investigation, we found that heel portion was the hotspot point from where we could generate maximum power. This technique is suited for everymen if he wants to produce power from his own footstep. The produced power could be used for charging small electronics devices i.e; lamp, mobile, laptop.

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