

## **STUDY OF ENERGY GENERATING SHOES**

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### **ABSTRACT**

*In today's world technology has gone so far and it became essential for the developed and the developing nation. This advancement can work through helping such innovation on renewable energy that we are experiencing nowadays. Walking is part of our daily routine; when we walk, our heel portion of the foot touches the ground first. It is followed by the mid foot and then the front part of the foot which is also known as Metatarsal region. The forward motion which we get while walking is because of the force applied by the body via the metatarsal region onto the ground. By Newton's third law, the ground exerts equal and opposite force on the foot. The total force applied by the body is in between the range of 400 to 700 Newton per step per leg depending on the gender, age and various other criteria. An Energy generating shoe is the concept that aims on reducing the expenditure of human energy while walking. When we walk, the heel portion of the foot touches the ground first. The entire weight of the body stresses the heel region of the foot. Energy generating Shoes absorbs the potential energy of the body by using the heel region of the foot to compress metal plate or impact metal plate on piezoelectric material. During the takeoff of the foot, this stored energy in the form of electric charge is used to charge batteries .It have a various application for used these stored energy. Like charge a batteries, to charge mobile, to charge gear and etc.*

### **I. INTRODUCTION**

People of all ages spend a lot of time walking. As it's indispensable in the daily life. We spend a great deal of our energy on walking. It not just tires our body, but also tends to deteriorate various parts of the body like knees, ankle tendons etc. It is necessary to develop devices to reduce energy expenditure of the body while walking as it will not just aid in making the most important task of our daily life easy, but also save us from various walking related problems that can ultimately lead to surgeries. Use of external powered units can be unreliable and tend to add a lot of weight. It's needed to develop a light medium that can incorporate the idea of reducing the energy expenditure of the body without requirement of any external source of energy. Energy generating shoes is conserving technique which depend upon piezoelectric effect can be used to reduce the expenditure. In this technique the excess energy spent by the body is stored in the form of electric charge and utilized when required. This concept is being used for various applications. Utilizing this concept can aid us to reduce the energy expenditure of the body with minimal requirement of external equipment, as the main power source would be the potential energy of the body.

## II. GAIT CYCLE

The gait cycle describes how humans walk and run – in other words, how we move. Having an idea of the gait cycle would help us to understand how we can implement the concept of energy generating shoes onto our feet in our gait cycle.

### The two phases of gait cycle

- A complete gait cycle begins when one foot makes contact with the ground and ends when that same foot makes contact with the ground again. It is made up of two phases:
- Stance phase during which (part of) the foot touches the ground;
- Swing phase during which that same foot doesn't touch the ground.

### 2.1 Stance Phase

Stance is considered the most important phase, because this is when the foot and leg bear your body weight. The stance phase can in turn be divided into three stages:

1. Initial Contact
2. Midstance
3. Propulsion

Let's take a closer look at each of these gait cycle phases.

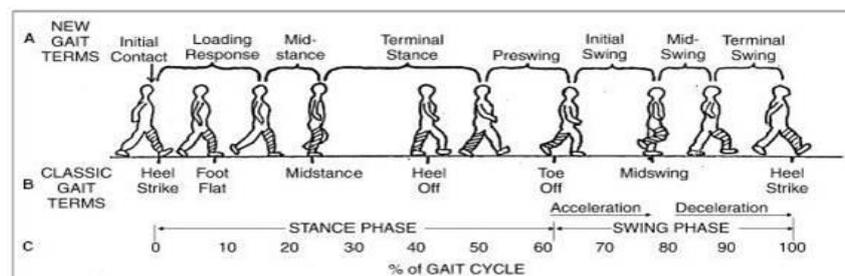


Fig 1. Gait Cycle

#### 2.1.1 Initial Contact

Initial contact is when your foot lands on the ground. It is the cushioning phase of the gait cycle. The knee flexes just before the foot hits the ground and the foot pronates (rolls in). This causes the foot and leg to act together as shock absorbers. The initial contact phase begins when the foot makes contact with the ground, usually heel first. It ends when the forefoot makes contact with the running surface. This moment is called 'foot flat' and it marks the beginning of the midstance phase.

#### 2.1.2 Mid Stance

During midstance the foot and leg provide a stable platform for the body weight to pass over. By now the foot should have stopped pronating. If the foot is still pronating at this time there is too much movement and instability. Also called single support phase, midstance is when the other foot is in swing phase, so all the body weight is borne by a single leg. This also means that the lower limb is particularly susceptible to injury.

#### 2.1.3 Propulsion

Propulsion is the final stage of the stance phase. It begins immediately as the heel lifts off the ground. As the big toe turns upwards (dorsiflexes) the windlass mechanism comes into play, tightening the plantar fascia and

helping to raise the arch of the foot. This mechanism is very important since it allows the foot to act as an efficient lever.

## 2.2 Swing Phase

The swing phase begins with 'toe off' and ends just before the foot makes contact with the ground again and a new gait cycle starts. This phase is important to set the foot and leg up in preparation for heel contact and the next stance phase.

## III. PRESSURE DISTRIBUTION IN GAIT CYCLE

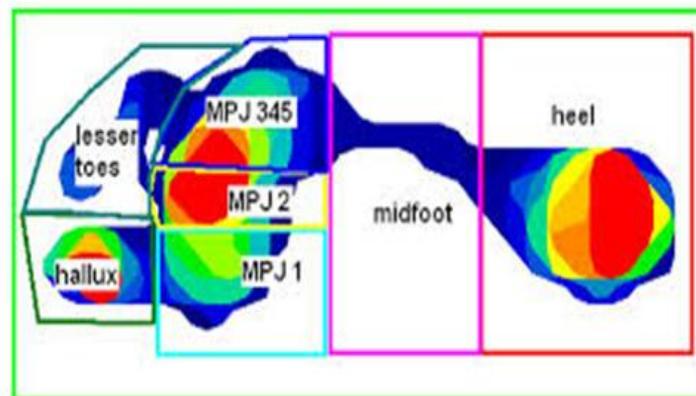
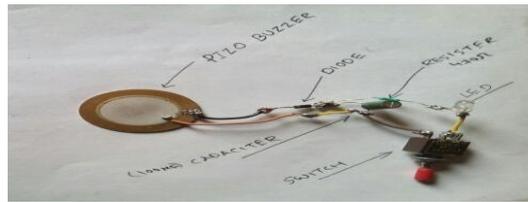


Fig 2: Parts of the Sole of the foot shown are Hallux, lesser toes, Metatarsals, Midfoot and Heel(Calcaneus).

### 3.1. A sample work by HuaShiu Peng and Yen Shia- Hasu at CoDe lab of Carneige Mellon University under guidance of Prof. Mark D. Gross

A person's weight is not allocated symmetrically over the plantar. As the sole is not flat but arched, the weight mainly centers on the hallex, the first metatarsae and the calcaneus. When sitting, the weight of a person's upper body rest mostly on the chair and the weight on the feet is relatively small. When standing, the whole body's weight is put evenly on both feet. Leaning left or right changes the weight distribution over the feet. When walking, the weight distribution changes with the pace; the weight on the front and rear part of the foot alternately increases and decreases because not all parts of the sole contact the ground at once. The changes in weight distribution on the feet reflect one's activity, and different activities have different changes of weight distribution signatures.

The hardware platform consists of a pair of ordinary canvas shoes, a pair of sponge insoles, piezoelectric plate, diode, capacitor, resister, plug, transmitter, receiver and rounded metal part. The piezoelectric plate underneath the insole and it connected in series to the diode. Rounded metal part is placed exact above piezoelectric plate at some distance. Then capacitor is connected in parallel to these circuit and then resister is connect in series. Now these whole ckt is connected to a plug. Then transmitter is attached to plug. We are discussed about energy generation so finally receiver is attached to mobile in charging slot or any external storage source.



**Fig 3: Actual circuit of piezoelectricity generation.**

## IV. INCORPORATION OF PRESSUREIZED AREA OF SOLE FOR ENERGY CONSERVING CONCEPT

The pressure distribution during Gait cycle follows as such.

- 1) Weight of the body acts downward on the heel during the Heel Strike.
- 2) When the Heel lifts from the ground, the metatarsal region of the sole is stressed.

Let us see how we can incorporate the concept of Energy Conservation In the gait cycle.

**4.1 Initial Contact:** It's the portion when our heel touches the ground. That's the point when the entire potential energy from our body in traversing from the feet into the ground. Using this energy is the main aim of energy generating Shoes and implementing Energy Conservation Principle. The potential energy of the body is to be stored and used.

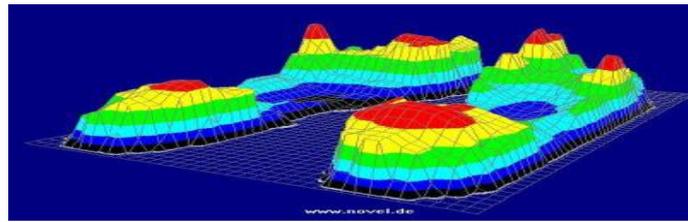
**4.2 Midstance:** It's the portion of the gait cycle when our entire foot has body touched the ground. It's the point when we need to ready the actuators for the takeoff.

**4.3 Propulsion:** It's the portion of the gait cycle when the heel is off from the ground and only the toe portion of the foot is in contact with the ground. At this point we push the ground downward as well as backward and push ourselves forward in the process. It's at this point that we need to make use of the energy stored during the initial contact. Making use of this energy would reduce the energy expenditure of the body for pushing the body forward during walking.



**Fig 5: Pressure of the stressed areas**

The approximate Pressure applied onto the ground during heel strike is 385 KPa. This pressure applied due to the potential energy of the body is wasted. And body has to spend its energy to apply pressure of 147Kpa for the forward stroke. The approximate force required is 600N to 750N.



**Fig 6: Pressure Distribution During Gait Cycle**

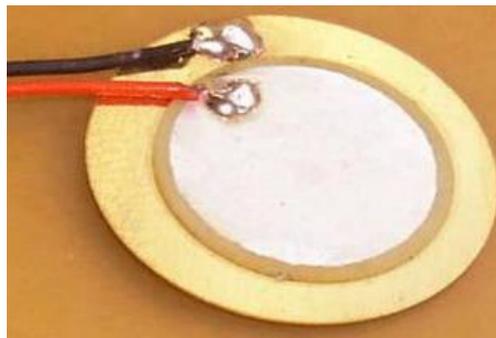
## 5. Energy generating shoes Components

Energy generating shoes systems consist of multiple components that work together or in sequence to perform some action or work. People well versed in energy generating shoes circuit and system design may purchase individual components and assemble them into a energy generating system themselves. However, many energy generating systems are designed by distributors, consultants, and other professionals who may provide the system in whole or in part.

The major components of any energy generating system include:

### 5.1 A piezo plate buzzer

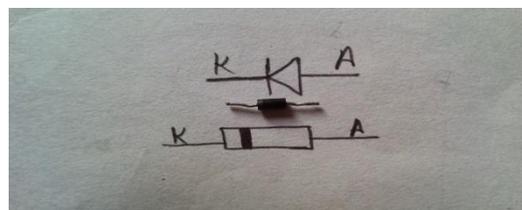
We can use piezoelectric material similar to the figure. As it serves the general purpose of generating electricity under application of external force, which in our case would be weight of the body



**Fig 8: piezoelectric plate.**

### 5.2 Diode

Here Diode is used to stable the voltage that coming through piezo plate.



**Fig. Diode**

### 5.3 Capacitor

100  $\mu$ F capacitor is used to store the voltage which produced by the piezo plate.



**Fig. capacitor**

## 5.4 Resister

470  $\Omega$  resister is used here to manage the voltage.



**Fig. resister**

## 5.5 Plug

Plug is used for connecting element between two devices. There are various types of plugs as shown in the figure.



## 5.6 Transmitter & Receiver

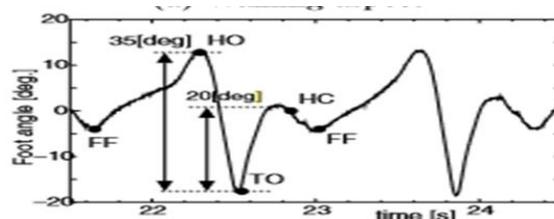
Transmitter & Receiver are used for wireless power transmission which is shown in following fig. Transmitter is connected in shoes plug & receiver is connected to storage device like Mobile.



**Fig. Transmitter & Receiver.**

## VI. CONCEPT OF ENERGY GENERATING SHOES

- The main aim of developing the energy generating shoes is to utilize the potential energy of the human body to help us reduce energy spent on walking.
- Equipment have been developed so far that aim to reduce the energy expenditure while walking, such as, using piezoelectric plate as an energy generating material, using this circuit arrangement. However these piezoelectric material equipment generally require energy like an impact energy, this shoes consist of circuit which may bring problems of cost, total weight and reliability, etc. We plan to develop Energy Conserving Shoes using nothing but human potential energy. One of the most important concept that we need to understand is the angle orientation of the feet during walking. Because when we walk our feet is inclined to the ground at an angle and not parallel.



(b) Foot angle in the walking motion

Figure 1: Foot angle trajectory

Figure shows the angle of ankle joint during walking. Angle of ankle joint at vertically standing situation is set as standard condition and dorsiflexion direction (direction of rising toe up) is set as positive. From the state of whole surface of foot contacts with ground (Foot Flat : FF in the figure), the angle of ankle joint is increased along with forward tilting of a body and it reaches at maximum value when a heel leaves ground (Heel Off : HO). After that, the angle is rapidly decreased until toe leaves ground (Toe Off: TO) by the motion of kicking foot backward to obtain thrust forward and then dorsiflexion motion is implemented. In this time, the dorsiflexion angle of aged person is reported to be smaller.

The above concept is important, as the angle of actuation would be dependent on the Foot angle. The angle from Heel Off to Toe Off is of more importance to us.

The way to utilize the potential energy of the body is by using a metal part at the heels to impact on piezoelectric plate. The weight of the body (Potential energy) would act as the prime source of energy. This energy would be stored as electric charge by using circuit. During the process of walking this energy is transmit by using transmitter to receiver which is connected to our mobile charging plug.

### 6.1 The concept of piezoelectric material

1. Normally, the charge in a piezoelectric crystal are exactly balanced, even if they're not symmetrically arranged.
2. The effects of the charge exactly cancel out, leaving no net charge on the crystal faces. (More specifically, the electric dipole moments- vector lines separating opposite charge – exact cancel one another out )
3. If you squeeze the crystal (massively exaggerated in this picture!), you force the charges out of balance.

- Now the effect of the charges (their dipole moments) no longer cancel one another out & net positive & negative charges appear on opposite crystal faces. By squeezing the crystal, you've produced a voltage across its opposite faces- and that's piezoelectricity.

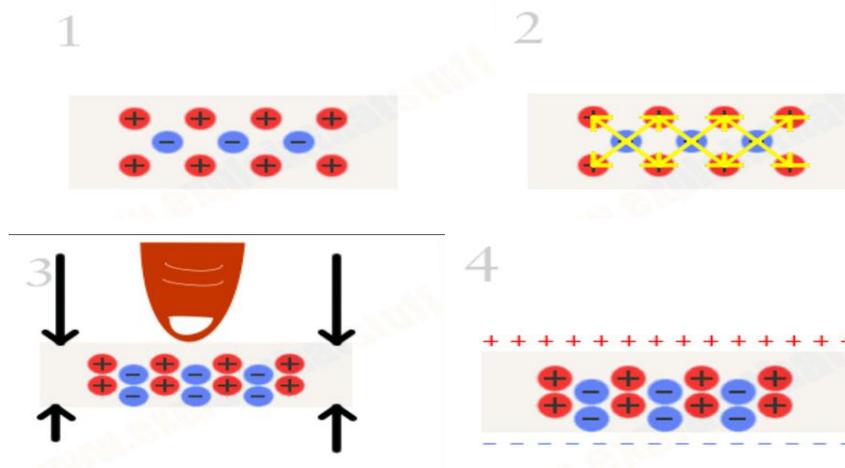


Fig. piezoelectricity concept.

## VII. WORKING OF ENERGY GENERATING SHOES

- At the start state of contact period while walking, a wearer step on a piezoelectric plate with their weight.
- The compressed or impacts piezoelectric plate is used as electric charge generator. When charge is generated then its flows though a circuit which is shown in following fig.

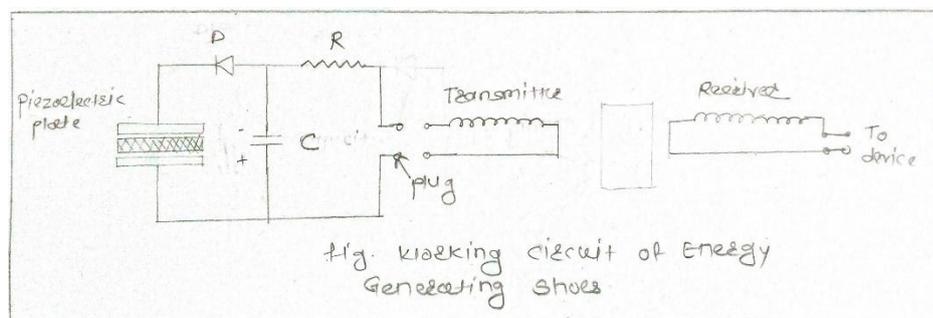
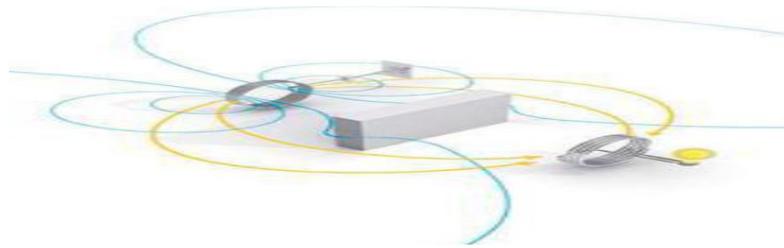


Fig. Working of energy generating shoes.

- This circuit consist of diode which is connected in series. Capacitor which is connected in parallel diode. Now resistor is connected in series. At the end of circuit plug is attached for connecting transmitter.
- Diode is used for converting A.C. into pulsating D.C. also rectifier is used and it may be a half wave or a full wave rectifier.
- capacitor is used to store the voltage which is produced by the piezo plate
- Resister is used here to manage the voltage.
- Now the transmitter is plugged to that circuit and receiver is plugged to our device like Mobile.
- Working of transmitter & receiver is shown in fig.



**Fig. Actual energy transfer by coil representation.**



**Fig. Energy Transfer by coil representation**

- Experimental scheme consists of two Selfresonant coils. One coil (source coil) is coupled inductively to an oscillating circuit; the other (device coil) is coupled inductively to a resistive load.
- Self-resonant coils rely on the interplay between distributed inductance and distributed capacitance to achieve resonance. The coils are made of an electrically conducting wire of total length and cross-sectional radius, wound into a helix turns, radius, and height.
- Here energy is transferred from transmitter & receiver is used to charge the mobile.

## VIII. FEATURE OF ENERGY GENERATING SHOES

- It can help in ease in walking for elderly: The force required by elderly people while walking is 1.2 to 1.3 times the force/energy required by the young.
- This force or pressure is used for energy generation & it's a conventional way.
- So, the expenditure of human energy while walking is usefully converted into conventional energy.
- This shoes are compact in walking & this assembly is not disturb in walking.
- More convenient
- No manual recharging or changing mobile batteries.
- Eliminate unsightly, unwieldy and costly power cords.
- Never run out of battery power.
- Reduce product failure rates by fixing the weakest link': flexing wiring and mechanical interconnects.
- Reduce use of disposable batteries.
- Use efficient electric grid power 'directly instead of inefficient battery charging

## IX. RESULTS AND DISCUSSIONS

- You know that, to become our body healthy exercise is necessary. In exercise process jogging is an important exercise. If you think overall our country number of people is doing jogging at daily morning. So this shoes is effective to produce conventional energy in the form of charge mobile.

- In daily routing of peoples, maximum work is not completed without walking. Peoples are spend their maximum times in walking. So it's also maximum energy generation from that shoes
- If peoples used that shoes, their mobile never be required charger. So production cost of charger is reduce.
- Due to this shoes, electricity is saved which is required charge mobile.
- This is conventional energy is absolutely free. So peoples eliminated cost of charging mobile.
- Elderly males and females have 1.12 times and 1.20 times greater maximum forces over the whole areas on the foot during walking as compared to younger males and females
- And walking is important in all direction.

## IX. CONCLUSION

Various studies prove that it's necessary to create conventional way to generate energy. It's also needed to utilizes the energy expenditure of the human body for the most basic task of walking as this energy can be used for something more useful. Energy generating Shoes meet these necessities and can aid us with it. It's not just useful for health but also for adventure to generating energy by using foot. It's an easy and basic concept that can be implemented without much hindrance.

We have studied various concepts relating to the piezoelectric effect which is useful to generate energy.

We focus on new generation energy transformation and it gives new platform for energy storage. Conserving principle and ease with which it can be implemented in shoes. We have also seen the various advantages of energy generating Shoes. One of the advantage is to charge the mobile by utilizing the stored energy of shoes by using wireless energy transfer.

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