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Piezoelectric Foot Step Energy Harvesting System: A Case Study

*K.*Sathish[1], *Dr K.*Mallikarjuna[1*], *C.Siva* Prasad[1], , *M.Ganesh* [1],*J.*Jayachandra [1], *P.Chand* basha [1]

[1] Department of ME, GPCET, KURNOOL

Abstract. A solution to the world's demand for sustainable energy is the Mechanical Footstep electricity Generator (MFPG), which generates electricity through human movement. Because we aim to turn every step into a substantial source of renewable energy and recognize the untapped potential of urban foot traffic, we are looking into mechanical energy collecting. The MFPG relies on a complex interplay between mechanical components that are positioned precisely beneath potentially walking surfaces. Spring pressure, a rack and two pinion system, and vertical foot pressure all work together to convert motion into rotation, which drives a generator to produce electricity. This innovative mechanical technique uses the regularity of human movement to produce power in a sustainable manner. The idea, planning, and implementation of the Mechanical Footstep Power Generator demonstrate the fine technical details needed to optimize energy extraction efficiency. Through rigorous testing and analysis, we evaluate the MFPG's performance, accounting for factors such as environmental adaptability, mechanical efficiency, and scalability. The Mechanical Footstep Power Generator idea is a step toward a more environmentally friendly and sustainable future.

KEYWORDS- MFPG, Footstep Power Generator, walkable surfaces, pinion mechanism

1 Introduction

In the search for sustainable energy solutions, the use of cutting-edge technology becomes even more important. In the challenging job of fulfilling rising energy demands while minimizing environmental consequences, engineering innovation and the need for renewable energy may coexist, as demonstrated by the Mechanical Footstep Power Generator. This project aims to create a viable power source from the mechanical energy generated by human foot traffic. One untapped resource is the steady stream of people in public areas and cities. The Mechanical Footstep Power Generator seeks to harness this

* Corresponding author: mallikarjuna.gtl@gmail.com

latent energy and transform it into electrical power through the use of carefully designed mechanical devices.

Mechanical components like a rack and two pinion system and springs are incorporated using this technology and are positioned strategically beneath walking surfaces. When combined, these components convert the vertical force of footfall into rotational motion, which drives the production of energy by a generator. In addition to efficiently capturing energy, this method aims to develop a discrete, sustainable power generation system that can be seamlessly integrated into our daily life. Our goal is to comprehend the technological details, challenges, and potential benefits of this innovative method of energy harvesting from foot traffic. We will use materials science, mechanical engineering, and careful design to make it happen. We aspire to create a new approach to clean, renewable energy generation, one step at a time.

2 WORKING PRINCIPLE:

A foot step arrangement is a mechanical device that smoothes or dampens shock impulses and converts kinetic energy into another form of energy, usually thermal energy, which dissipates easily. It's somewhat of a dashpot. A footstep is a device that converts mechanical energy into electrical energy. The pushing power may be converted into electrical energy with the correct drive configuration. The reciprocating mechanism and rack and pinion system are fastened at the step. The spring is used to return the inclined step to its starting position when the weight is withdrawn. This is an example of a permanent magnet D.C. generator. It generates 12 volts D.C.

2.1 HARDWARE SETUP:

This section examines the project's block diagram as well as the design of separate modules. Fig. displays a block diagram.

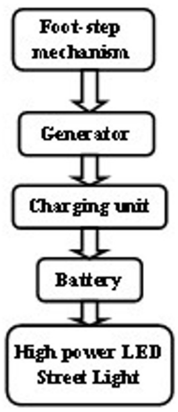

Fig. 1 Block diagram of construction of Piezoelectric Foot Step Energy Harvesting System.

2.2 RECIPROCATING MECHANISM:

A repeating up-and-down or back-and-forth linear motion is known as reciprocating motion, or reciprocation. It may be found in many different devices, including as pumps and reciprocating engines. Strokes are the two opposing motions that make up a single reciprocation cycle. The reciprocating pinion is fastened to a tubular pinion shaft in the reciprocating mechanism, which also holds the rotor rotatably to the spinning reel's body and extends via a primary shaft that supports the spool. In front of the rotor drive pinion that is in contact with a master gear is the reciprocating pinion.

2.3 EXISTING SYSTEM:

The amount of energy we need is growing daily, and we are having trouble meeting this demand. Thus, attention to alternate energy sources becomes important. The graph illustrates the rise in energy use between 1973 and 1998. Tidal, wind, and solar energy are a few examples of alternative energy sources.

2.4 Theory:

Bhavya K R[1], focused on Advanced Footstep Power Generation System Using RFID for Charging It looks at several energy harvesting techniques and talks about RFID's potential for data transfer and wireless charging. The analysis lays the groundwork for future studies in sustainable energy solutions by highlighting issues such as power transmission. Footstep Power Generation by Sarat Kumar Sahoo[2], The efficiency, scalability, and viability of several approaches, including piezoelectric materials, electromagnetic induction, and mechanical energy harvesting systems, are examined in this research. It offers insightful information on the sustainable production of power from foot traffic by going over design concerns, optimization strategies, and the viability of integration into actual surroundings. Creation of a footstep power generator to generate electricity from kinetic energy, Chun Kit Ang[3] addressed the design characteristics of the generator are included in the research, along with structural factors, energy conversion methods, and material choices. It also looks at the generator's performance indicators, including power production, efficiency, and dependability, providing information about how well it may work in renewable energy systems.

3 HARDWARE DESCRIPTION:

3.1 Foot Step Mechanism

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Fig .2. view of foot step mechanism

The configuration seen in the image turns the flywheel whenever foot force is applied since it generates mechanical energy. A DC generator receives this energy and transforms it into electrical energy.

3.2 Spring

Typically, a spring is a tightly coiled coil or spiral of metal that, when pulled (a force is applied), expands and returns to its original shape when released (a force is removed). That is to say, a spring is elastic. By elasticity[4], I don't mean that it's composed of rubber. In addition, depending on the spring's construction, it may contract when squeezed yet revert to its initial length when the pushing force is released. Springs are an excellent way to absorb or store energy[5]. When a spring is stretched by applying a pushing or pulling force across a distance, work and energy are being used in physics.

Fig.4. Spring

3.3 D.C Generators

A device that transforms mechanical energy (or power) into electrical energy (or power) is called an electrical generator. According to Faraday's law of electromagnetic induction[6], it produces induced electromagnetic fields. If the conductor circuit is closed, this e.m.f. results in a current flowing. Therefore, an electrical generator's two fundamental components are:

3.3.1. Determine the torque

Let's say you need to figure out how much torque is needed to move a conveyor belt, lift a weight, or accelerate a wheel. You may simply translate the torque necessary for another arm length if you know how much force is needed at one radius (arm length) of leverage[7]. Torque = Perpendicular Force x Radius about the center of rotation is the pertinent equation.

Fig.5. DC generator

Sketch a schematic of a pulley wheel with a mass m falling off of it and a radius of R.

1. This example may be used to a variety of torque situations in which the load exerts[8] a force perpendicular to the center of rotation at a radius R.
2. Calculate the force that the mass produces. Here, F=ma=mg is obtained using Newton's second rule, where g is the gravitational acceleration constant, or 9.80 m/s squared.
3. Determine how much tension you must exert on the pulley to prevent the weight from falling. Stated otherwise, the required torque is FR = mgR.

Therefore, a motor must provide a force of F = mgR/r in order to drive a wheel of radius r that is connected to the same axle as the pulley. Rotational Force is shown in Fig.6

Fig.6. Rotational force

3.3.2 Rotational Force Calculation

The force of an item revolving around a central axis or pivot is measured by rotational force[9], which is sometimes referred to as torque or centripetal force. For instance, turning a bolt with a wrench generates sufficient force to either tighten or loosen the bolt. The rotational force that is produced is the force that results from spinning the wrench.

3.4 DC motor gears increase torque

Due to their differing radii, two gears of varying sizes can enhance or decrease torque[10]. The torque you produce is equal to the force times the gear's radius if you (or another gear) apply a tangential force at the gear's edge, where the teeth are located.
When a 1 inch wide gear is driving a 4 inch wide gear with 10 foot-pounds of torque on it, the 4-inch wide gear receives 40 foot-pounds of torque since its radius is four times that of the smaller gear. The torque is inversely proportional to the rotational speed, to put it another way. The torque doubles when the speed is cut in half.

Fig.7. DC motor

Conveyor belt drives, home appliances, platform and disability elevators, medical and laboratory equipment[11,12], machine tools, packing machinery, and printing presses are just a few of the popular devices that employ gear motors.

3.5. BATTERY RECHARGEABILITY

One kind of electrical battery is an accumulator, storage battery, or rechargeable battery. It is a form of energy accumulator and consists of one or more electrochemical cells. Because of the electrical reversibility of its electrochemical processes[13,14].

Fig.9. 12V battery

3.6 HIGH POWER LED

Philips Lumileds Lighting Company high power LEDs are installed on a 21 mm base metal core PCB in the shape of a star. Unlike ordinary LEDs[13], which need currents in the tens of milliamperes, high power LEDs (HPLEDs) may be driven at currents ranging from hundreds of milliamperes to more than one ampere. They may generate more than a thousand lumens. The HPLEDs must be placed on a heat sink to allow for heat dissipation[15,16] because overheating is harmful. An HPLED will burn out in a matter of seconds if the heat is not dissipated. A flashlight's incandescent bulb may frequently be replaced with a single HPLED, or it can be arranged in an array to create a strong LED lamp.

4. RESULTS ANALYSIS

By only exerting energy on the foot step, the "Foot step power generation system" project was created to produce electricity in an unconventional way. Footstep is a non-traditional energy source that uses a reciprocating mechanism to transform mechanical energy into electrical energy. The transformation of force energy into electrical energy for this project. Rack and pinion, D.C. generator, battery, and basic reciprocating mechanism control are all carried by the control mechanism. We have spoken about the different uses as well as future extensions. This project makes use of a Permanent Magnet D.C. generator. The reverse polarity preventer/polarity corrector receives the output of this DC-geared motor.

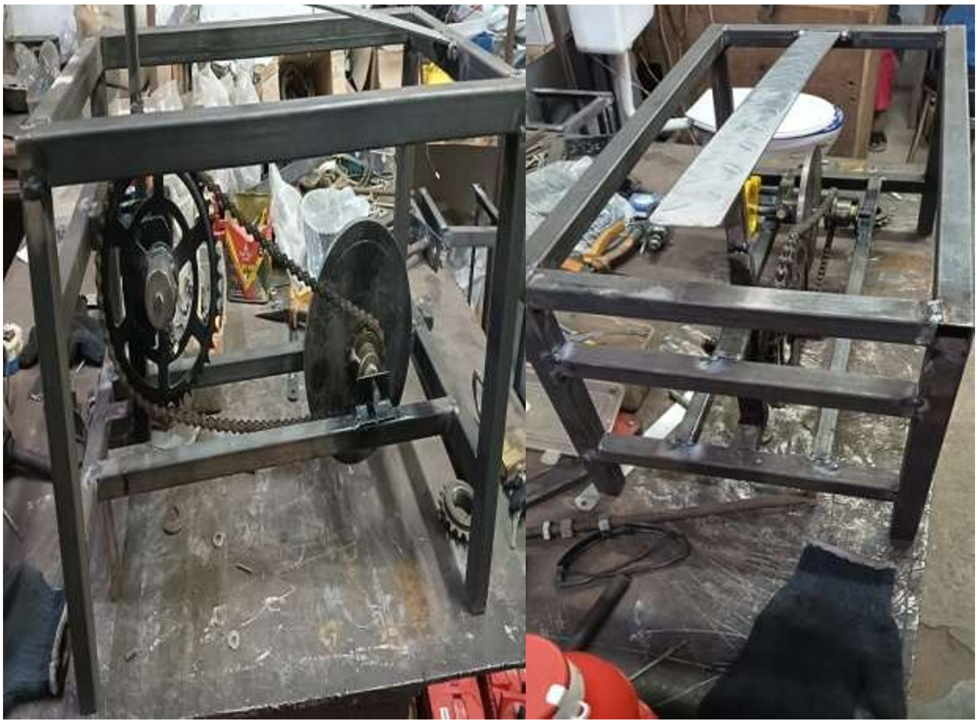

Fig. 9. Final Design of Piezoelectric Foot Step Energy Harvesting System.

Fig.10. Rack and Pinion mechanism

Table 1 Data Table For Analysis Of Pefse For A Weight Of 55 Kg

Battery Capacity (mAh)	**Charger Current (mA)**	**Charging Time (hrs)**	**Charging Time (hrs & mins)**
2400 mAh AA	100 mA	28.8 hrs	28 hrs 48 mins
2400 mAh AA	100 mA	28.8 hrs	28 hrs 48 mins
2400 mAh AA	100 mA	28.8 hrs	28 hrs 48 mins
2400 mAh AA	100 mA	28.8 hrs	28 hrs 48 mins
2400 mAh AA	100 mA	28.8 hrs	28 hrs 48 mins

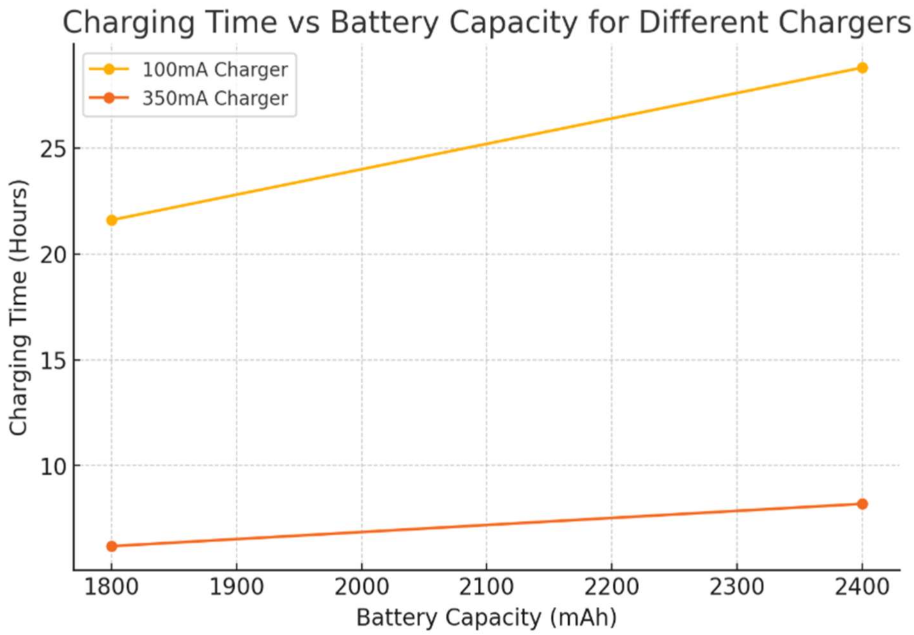

Fig 11 a plot between battery capacity vs charging time

Inferences- From graph it is observed that as the battery capacity increases charging time increases for different chargers

5 CONCLUSION:

The design incorporates features that seamlessly integrate all utilized hardware components. Each module has been carefully evaluated and strategically placed to enhance the overall functionality of the unit. Furthermore, the project has been successfully implemented through the use of advanced technology and highly sophisticated integrated circuits. Consequently, the project has been produced and tested with satisfactory results. To sum up, the footstep energy generating system presented offers a creative and useful method of capturing the kinetic energy of human footfall. The force applied by walking is efficiently converted into rotational motion by means of springs, rack and pinion, and gear systems, which in turn produce electrical power via the attached generator. The setup's effort, the weight of the person walking, and the frequency of footsteps are some of the variables that affect the system's efficiency. Individuals who weigh more and walk more frequently clearly contribute to higher energy production. An important design decision that significantly increases power output is the integration of a rack and two pinion sets onto a single footstep base. The primary goal of our research, "Foot step based power generation system," is to produce electricity using an unconventional method—just walking or jogging on foot steps. Footstep is a non-traditional energy source that transforms mechanical energy into electrical energy. In the future, this technology may be installed in buildings to produce electricity using a basic spring mechanism or, alternatively, generators that can produce large amounts of power.

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