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Feasibility study on generation and storage of power generated by mechanical footstep power generator

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Abstract

With the increasing demand for electrical energy in today's world, science has discovered many new concepts and methods for energy production. Among those concepts, a mechanical footstep power generator converts mechanical energy to electrical energy. The ultimate purpose of this research is to fabricate the footstep power generator and to produce electrical energy. The project is based on a Rack and Pinion mechanism to convert mechanical energy into electrical energy by utilizing energy during walking. The maximum voltage and current output of 8.22 Volt and 0.12 Ampere were obtained when the maximum load of 70 kg was applied to the system. This research has shown that mechanical footstep power generators have great potential for powering small electrical devices in various public places.

Keywords: Footstep; Pinion; Power; Rack

1. Introduction

Man has needed energy at an increasing rate for his sustenance and well-being ever since he came to the earth. Due to this, many energy resources have been exhausted and wasted. The concept of harnessing human motion to generate electricity has gained attention due to its potential to contribute to the growing energy requirements while minimizing the environmental impact [1]. Walking, a fundamental human movement, creates contact between our feet and the ground, producing a reaction force that can be converted into useful energy. This energy is usually lost as the impact during each step, but it has the potential to be captured and transformed into electrical energy [2].

Two methods can be employed to generate electricity by using Footsteps. The methods include piezoelectric energy harvesting and mechanical footstep power generation. However, the amount of power generated by the piezoelectric method is still at the mW level [3]. So, this paper focuses on the feasibility of the generation of electricity by using a mechanical footstep power generator.

A Mechanical Foot-Step Power Generator (MFSPG) represents the concept based on a rack and pinion mechanism to generate electricity by harvesting footstep energy during walking. The fundamental parts employed in the MFSPG encompass the rack, pinion, shaft, springs, spur gears, bearings, DC generator, and light bulb. The rack is affixed to the footstep plate, engaging with a spur gear. This spur gear is connected to a DC generator through a secondary gear. The role of the DC generator is to generate electric power. Consequently, the linear motion transforms into rotational motion, facilitating electrical energy generation. The MFSPG model is depicted in Figure 1.

2. Materials and Method

2.1 Methodology

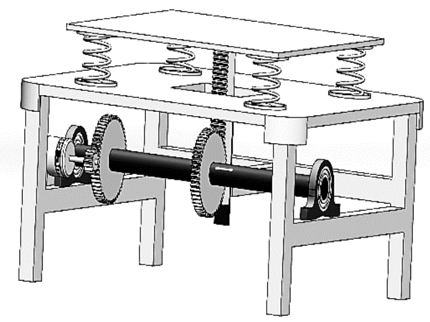

Figure 1: Model of MFSPG

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The experiment began with thorough research involving diverse sources, including papers and books. Key findings from these sources were noted for reference. This information guided identifying necessary components, with their specifications calculated analytically. Using modeling software, 3D models of components were created, followed by analytical assessments. During fabrication, certain component specifications were adjusted due to market limitations, with minimal anticipated impact on system performance. Upon component completion, assembly of the mechanical footstep power generator took place. Subsequent testing confirmed satisfactory results, as voltage and power output were measured under specific load conditions.

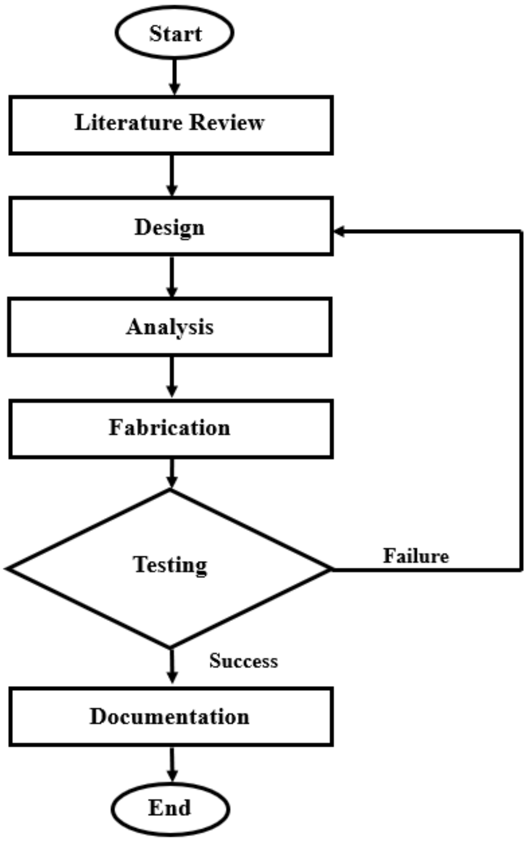

Figure 2: Methodology flowchart

2.2 Materials

The material and specification of the assembly components are tabulated in Table 1.

Table 1: Components and their specifications

Components	Dimension	Material
Footstep Plate	300×300×2 mm	Mild Steel
Frame	350×350×270 mm	Mild Steel
Pinion	48 mm diameter 20 teeth	Cast iron
Rack	225mm 34 teeth	Cast iron
Shaft	20 mm	Mild Steel
Spring	Outer diameter 24 mm Inner diameter 19.5 mm	Mild steel (ASTM A227)
Bearing	20mm Bore 52 mm Outer diameter	Chrome steel

2.3 Working Principle

The weight exerted on the footstep is harnessed to produce electrical energy. As an individual walks, the device converts kinetic energy into electrical energy. A platform beneath the foot is positioned on springs. When pressure is applied to the platform, it descends, causing it and an attached rack to move downward. This rack is engaged with a spur gear, which rotates the attached shaft. The vertical movement of the rack is translated into the rotational motion of the spur gear. This rotational force is transmitted to a DC generator via a gear mechanism. Consequently, the DC generator's rotary motion facilitates electricity generation. The generated electricity is stored in a battery with a 6V and 5 Ah rating. The PN junction diode is used to obstruct the flow of current back from the battery to the generator. The schematic figure of the circuit is shown in Figure 3.

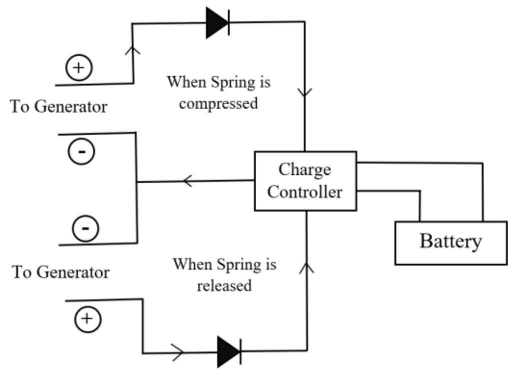

Figure 3: Circuit diagram showing Charging of Battery

3. Results and Discussion

3.1 Experimental Analysis

The prototype was tested by different weights, stepping gently to witness the amount of power generated by the system. The maximum value of voltage and Power with weight is plotted in Figure 4.

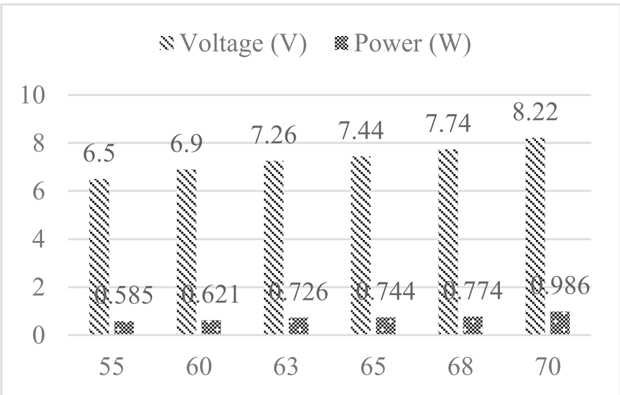

Figure 4: Voltage and Power vs. Weight

The study determined that voltage and power positively correlated with weight, observing higher values when individuals of varying weights gently stepped on the plate. A notable peak power of 0.986 watts and peak voltage of 8.22V was achieved with a 70 kg person applying pressure, devoid of external force, highlighting significant energy output potential. However, variations in walking behaviors among individuals contribute to potential fluctuations in generated power. With an average flow of 240 individuals per hour (equivalent to four persons per minute) and a person's weight of 70 kg, the generated voltage for a 70 kg person was 8.22V, accompanied by a current of 0.12A. Consequently, the power generated per step equated to 0.9864W. The charging time calculation considered the battery specifications (6V, 5Ah) and a charging rate of 0.12A. Given a duty cycle of 0.02, the average generator power output was 0.9864W. This led to a calculated charging time of 30.41 hours. Consequently, a total of 7,300 steps were determined as necessary to charge a 6V, 5Ah battery fully. An experimental discharge of a 6V, 5Ah battery to 40% was followed by a connection to the mechanical footstep power generator for charging. After 1,000 steps on the footstep plate, voltage measurements were taken every 100 steps, demonstrating an increase in battery voltage from 5.98V to 6.05V, as shown in Figure 5.

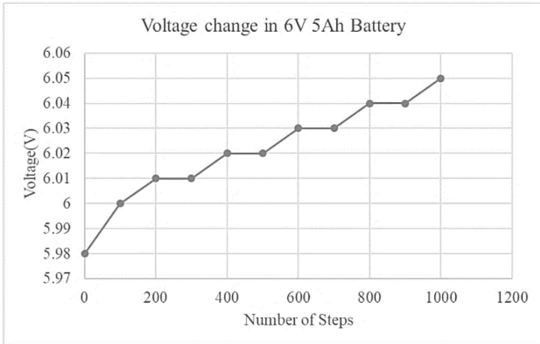

Figure 5: Number of steps vs Voltage

3.3 Calculation of payback period:

Total cost to fabricate MFSPG = Rs. 19,500
Per unit electricity cost in Nepal = Rs. 11
The average flow of people Per Hour
Weight of person=70 kg
For 70 kg person, Generated Voltage=8.22V
Generated Current=0.12A
Power Generated=V*I =8.22*0.12
=0.9864W per step
Total electricity generated per day
= 0.9864*240*4 (if it is operated 4 hours in a day)
= 0.946 kWh per day
Annual savings
= Total electricity generated per day * 365 days * Energy cost
= 0.946 * 365 * 11 = Rs. 3,798.19
Payback period = Fabrication Cost/Annual Savings
= 19500/3798.19 = 5.134 years
Hence, the payback period of a mechanical footstep power generator is 5.134 years.

4. Conclusions

In conclusion, this feasibility study has illuminated the potential of the mechanical footstep power generator as a viable and alternative energy solution. By effectively harnessing the footstep energy generated by human footsteps and converting it into electrical energy, this technology presents a low-cost and environmentally friendly option for power generation. The study successfully demonstrated the increase in the power output in relation to people's weight. A power output of 0.585 watts was generated by individuals weighing 55 kg when they stepped, and this power output increased to 0.986 watts for individuals weighing 70 kg when engaged in stepping. The analysis of the device's performance, coupled with calculations and experimental validation, showcased its capability to charge batteries and power small electronic devices. In 1000 steps, the charge was increased by 10% (From 40% to 50%), starting from a battery voltage of 5.98V to 6.05V. The study emphasized the adaptability of this technology in various settings, particularly high-traffic areas such as public spaces, schools, and universities. The collaborative efforts of researchers, guided by invaluable mentorship and resources, resulted in a comprehensive exploration of the mechanical footstep power generator's potential. As this technology bridges the gap between renewable energy and everyday human activities, it paves the way for a sustainable energy future.

Acknowledgment

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