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FABRICATION OF A FOOTSTEP POWERED ENERGY HARVESTING SYSTEM

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Abstract: The escalating demand for electrical energy and the fast depletion of traditional energy sources have made the researchers to explore towards the use of alternative and renewable energy sources. One such promising approach is the generation of electrical energy from human activities. This paper details the design and fabrication of a prototype of footstep-powered energy harvesting system that converts mechanical energy generated by human footsteps into usable electrical energy. The system comprises a mechanical arrangement, a power transmission mechanism, a DC generator, rectifier circuit, and an energy storage unit. When an individual walks over the footstep platform, the applied force is transformed into rotational motion using a rack and pinion mechanism, which subsequently drives the generator to produce electricity. The generated energy is stored in a rechargeable battery and can be utilized for low-power applications such as LED lighting. This prototype develops a power of 300 Watt per day when 120 persons put their step on it. The proposed system is cost-effective, eco-friendly, and suitable for installation in public places like railway stations, shopping malls, and educational institutions.

Keywords— Footstep energy, energy harvesting, renewable energy, rack and pinion mechanism, DC generator.

1. Introduction

Energy plays a crucial role in the economic and technological advancement of any nation. With the rising population and industrialization, the need for electrical energy has seen a significant surge. Conventional energy sources like coal, petroleum, and natural gas are finite and lead to serious environmental pollution. Therefore, there is a critical need to develop non-conventional and renewable energy sources that are clean, sustainable, and environmentally friendly.

Human locomotion offers a continuous and easily accessible source of mechanical energy. Each step taken by a human generates a certain amount of force, typically underutilized. Harvesting this mechanical energy effectively and converting it into electrical energy can serve as an additional power source. Footstep power generation is an innovative method that harnesses the pressure from human footsteps to create electricity. This project focuses on designing and fabricating a footstep-powered energy harvesting system using simple mechanical and electrical components. The recent research work presented a mechanical system in which the pressure generated from human footsteps was converted into rotational motion using a rack and pinion mechanism integrated with gear and chain drive systems. The rotational motion was

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then transmitted to a DC generator to generate electrical energy, and the produced power was further conditioned using an inverter system to obtain a usable electrical output [1]. The researchers also implemented a gear-based transmission system integrated with buck (LM2596) and boost (MT3608) DC–DC converters [2]. This approach ensured a stable 5 V output despite variations in footstep pressure by automatically selecting the appropriate converter for voltage regulation [2]. Recent research also utilized a spring-loaded rack and pinion mechanism to convert mechanical energy from human footsteps into electrical energy. The generated DC power was stored in a 12 V battery and later converted into 230 V AC using an inverter circuit for practical electrical applications [1, 2].

Electromagnetic induction was used as the fundamental principle for energy generation. The system employed rotating magnets inside a copper coil, driven by rack and gear mechanisms, to produce DC power, which was utilized for lighting LED arrays [3]. They demonstrated the use of a 10 V DC generator operating at 1000 RPM, coupled with a spur gear mechanism and a high-load spring system to convert footstep pressure into electrical energy. Ball bearings and a mild steel shaft were incorporated to minimize friction and improve the overall mechanical efficiency of the system [3]. A gear-based footstep power generation system utilized a crankshaft-driven mechanism connected to a DC motor operating as a generator, where an SPDT relay was employed to switch between buck and boost converters to maintain a stable electrical output. Another approach incorporated a flywheel and clutch system to smooth the intermittent motion produced by footsteps, enabling the system to generate approximately 12 V AC at around 1000 RPM and thereby improving power consistency [3, 4].

A research study focused on the design and modeling of a rack and pinion mechanism using CREO software for footstep power generation. The analysis highlighted certain limitations, including difficulty in handling variable loads and the absence of power generation during the return stroke. Another comparative study evaluated different energy harvesting mechanisms, including piezoelectric, rack and pinion, and piston-based systems, and concluded that rack and pinion mechanisms provide a better balance of efficiency, durability, and cost [5, 6]. A recent study proposed a footstep energy harvesting system using a belt-driven mechanism combined with a crank lever and timing belt assembly. The design incorporated a spring-return pedal and an optimized gear mechanism to effectively convert footstep pressure into electrical energy while accommodating users with varying body weights [7].

The primary objectives of this study are to design a simple and efficient mechanism for converting footstep force into electrical energy and to fabricate a low-cost footstep power generation prototype. The study also aims to evaluate the feasibility of harvesting energy from human walking and to store the generated power for practical applications. Additionally, the work seeks to promote awareness about renewable and non-conventional energy sources and their potential role in sustainable energy solutions.

2. Methodology

The operational principle of the footstep-powered energy harvesting system involves converting mechanical energy into electrical energy. When an individual step on the footstep

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platform, a downward force is exerted. This force causes the platform to move downward against a restoring spring. The linear motion of the platform is transformed into rotational motion using a rack and pinion mechanism. The pinion is linked to a shaft connected to a DC generator. As the pinion rotates, the generator produces electrical energy. Since the generator's output is not constant, a rectifier circuit is employed to convert the generated AC or fluctuating DC into a stable DC output. This output is then stored in a rechargeable battery. The stored energy can be utilized to power low-voltage devices like LEDs.

The key components used in this system include:

- Footstep platform
- Rack and pinion mechanism
- Compression springs
- DC generator
- Rectifier and voltage regulator
- Rechargeable battery
-Load (LED Bulb)

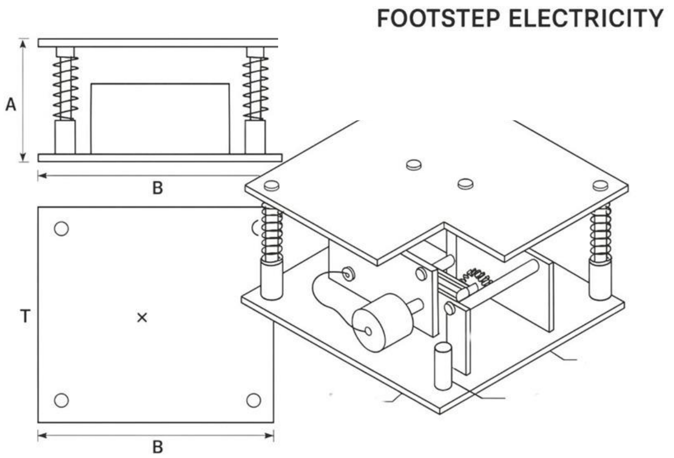

Fig. 1. Proposed Diagram of the Model

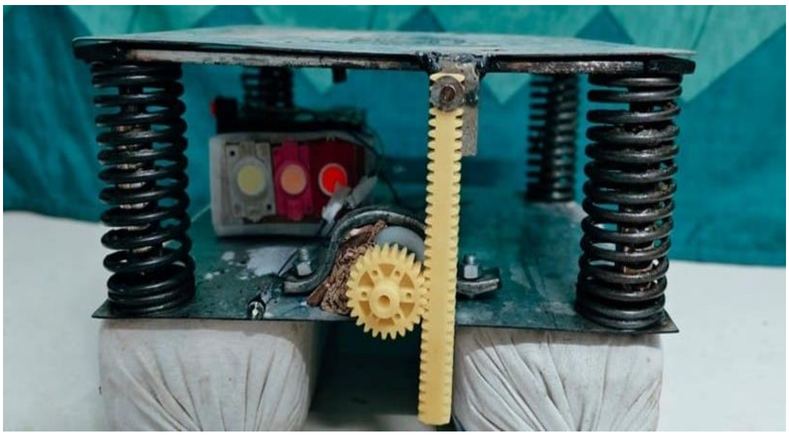

Fig. 2. Fabricated prototype of the Model (Side View)

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Fig. 3. Fabricated prototype of the Model (Top View)

Fig. 4. Energy Generated after Stepping of a Person

The footstep platform is designed using a sturdy metal or wooden base capable of supporting human load. Springs are positioned below the platform to allow vertical movement and restore the platform to its original position after each step. The rack is affixed to the underside of the platform, while the pinion is mounted on a shaft connected to the DC generator.

The entire assembly is enclosed in a protective frame for safety and durability. Proper alignment of mechanical components is maintained to minimize frictional losses and enhance efficiency. Electrical connections are established using insulated wires and suitable electronic components.

Calculations:

Average mass of a person (m) = 60 kg
Acceleration due to gravity (g) = 9.81 m/s^2
Height of spring compression (h) = 1.7 cm = 0.017 m
Force Calculation ($F = m*g$)
$F = 60*9.81$

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F = 588.6 N

Hence, the force applied on the system due to one person is 588.6 N.

Energy generated per step

E = m*g*h

E = 60*9.81*0.017 = 10.006 J

Thus, the energy produced in a single step is 10.006 Joules.

Power Generation and Efficiency Calculation:

The electrical power generated depends on the rotational speed of the generator and the energy produced per step.

Speed of motor (N) = 35 rpm

Revolutions per second = 35/60 = 0.583, rps

Power Generated, P = E*N

P = 10.006*0.583

P = 5.83 W

Hence, the theoretical power generated per person is 5.83 W.

Net Power Output Considering Efficiency

Number of persons stepping per day = 120

Assuming the system efficiency as 50%

Net Power = 5.83* 120 * 0.5

Net Power = 350.00 W

Net Power = 0.35 kW

Thus, the net usable power produced by the system per day is approximately 0.35 kW.

3. Results and Analysis

The experimental and analytical evaluation of the human-powered energy harvesting system demonstrates its feasibility for low-power electricity generation. From the calculations, a person with an average mass of 60 kg applies a force of 588.6 N on the system due to gravity. This force compresses the spring by 0.017 m, resulting in an energy generation of 10.006 J per step, as calculated using the principle of gravitational potential energy.

Table 1. Variation of Energy Generated with Spring Compression

Spring Compression (mm)	0.01	0.015	0.017	0.02	0.025
Energy Generated (J)	5.886	8.829	10.006	11.772	14.715

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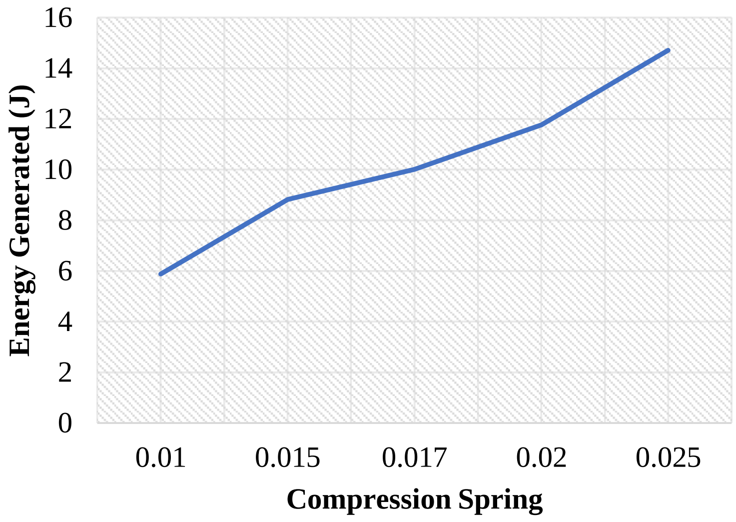

Fig. 5. Energy Generated vs Spring Compression

The above graph shows a direct linear relationship between spring compression and energy output, indicating that greater compression leads to higher energy generation. At the design compression of 0.017 m, the system achieves approximately 10 J per step, which aligns with the calculated value and confirms the effectiveness of the spring-based mechanism. This graph is particularly useful for optimizing system design, as it highlights how even small increases in compression can significantly enhance energy output.

Table 2. Variation of Power Generated with Number of Persons

No. of Persons	20	40	60	80	100	120
Power Generated (W)	58.3	116.6	174.9	233.2	291.5	349.5

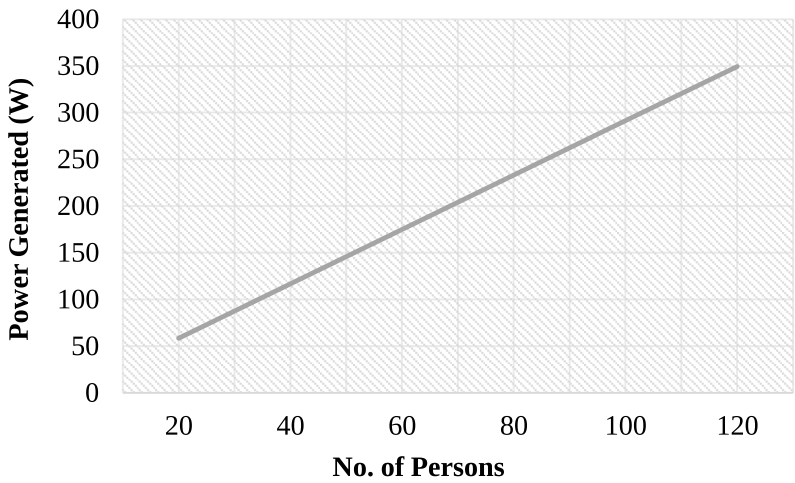

Fig. 6. Power Generated vs No. of Persons

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Further analysis of power generation reveals that with a generator speed of 35 rpm (0.583 rps), the theoretical power output per person is 5.83 W. Considering real-world losses and assuming an overall system efficiency of 50%, the above graph demonstrates that the total usable power increases linearly with foot traffic. For 120 persons stepping on the system per day, the net power output is approximately 350 W or 0.35 kW. This result confirms that while the power contribution from a single individual is small, the cumulative effect of multiple users makes the system practical for applications such as pathway lighting, information displays, or charging stations in high-footfall areas. Overall, the results and graphical analysis validate the theoretical calculations and show consistent linear trends between force, energy, and power generation. The system is therefore suitable for sustainable, small-scale energy harvesting, especially in locations with continuous pedestrian movement.

4. Conclusion

This paper successfully presents a footstep-powered energy harvesting system that effectively converts mechanical energy from human footsteps into electrical energy using a simple rack and pinion mechanism. The proposed model is economical, easy to implement, and environmentally friendly. While the amount of energy generated is relatively modest, it can serve effectively in public places for lighting and signalling applications. Future enhancements may include integrating smart energy management systems and expanding implementation on a larger scale.

5. References:

1. Patil, J. S., Sutar, N. R., Patil, P. V., Patil, R. R., & Sutar, S. S. (2021). Electricity generation from footsteps using rack and pinion method. International Research Journal of Engineering and Technology (IRJET), 8(4), 3177–3180.
2. Sutikno, T., Ady, A., Prasetiyo, A. W., Setiawan, E. E., Zulfahmi, Z., & Firdaus, I. S. (2023). Design and implementation of mechanical gear-based footstep power generation system using buck and boost converter. International Journal of Power Electronics and Drive Systems (IJPEDS), 14(1), 317–324.
3. Yadav, V. K., Singh, R., Kadam, M. B., Sarang, M. N., & Jadhav, R. K. (2020). Footstep power generation. International Journal of Engineering Research and Technology (IJERT), 9(5), 605–607.
4. Sutikno, T., Yulianti, Y., Ardi, A., Prasetiyo, A. W., Setiawan, E. E., & Satria, R. (2023). Footstep power generation using a mini DC motor with SPDT relay selector. International Journal of Electrical and Computer Engineering (IJECE), 13(2), 2225–2232.
5. Sutikno, T., Aji, N. F., Widanarto, W., Ardi, A., Prasetiyo, A. W., & Setiawan, E. E. (2023). Footstep energy harvesting using timing belts and spring-piston assembly. International Journal of Reconfigurable and Embedded Systems (IJRES), 12(1), 111–119.
6. Deshmukh, T. R. (2016). Foot step power generation system using rack and pinion mechanism. International Journal of Scientific & Engineering Research (IJSER), 7(6), 883–886.
7. Kumar, T. M., Gowtham, K., Vyshnavi, K., Ramya, K., & Balamurugan, C. (2015). Power generation in automobile suspension system. International Journal of Engineering Research and Technology (IJERT), 4(4), 119–122.