

Design and Fabrication of Footstep Power Generation System

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Abstract

This research paper presents the design, fabrication, and optimization of a footstep power generation system capable of converting human kinetic energy into usable electricity. The system employs a connecting rod and crank mechanism to transform the linear motion of footsteps into rotary motion. Spur gears are integrated to amplify rotational speed and torque, thereby enhancing energy conversion efficiency. The mechanical energy generated is converted into electrical energy using a low-RPM dynamo, which is then stabilized and stored in a battery for off-grid applications. This innovative approach combines traditional mechanical components with modern energy harvesting techniques, offering a durable and cost-effective alternative to piezoelectric systems. Performance metrics, including voltage output, energy storage capacity, and gear ratio efficiency, are evaluated through rigorous testing. The system generates 3V per footstep, effectively powering four 1.5V LED lights. Designed for scalability, this system demonstrates potential for deployment in high-traffic areas such as schools, transit hubs, and malls, effectively harnessing wasted kinetic energy. By addressing challenges such as material durability, energy loss, and precise gear alignment, the project highlights the viability of mechanical energy harvesting as a practical and sustainable renewable energy solution.

Keywords: Footstep power generation, kinetic energy, connecting rod and crank mechanism, spur gears, low-RPM dynamo, energy harvesting, renewable energy.

1. Introduction

Energy is one of the most essential resources in modern society, yet its generation often depends on non-renewable and environmentally harmful methods. As the global population grows, so does the demand for sustainable and renewable energy solutions. Human motion, an abundant yet underutilized source of kinetic energy, presents an innovative opportunity for power generation.

Footstep power generation is a concept that harnesses the energy produced by human footsteps and converts it into usable electrical energy. By integrating mechanical and electrical systems, this approach offers a practical method for energy harvesting, especially in high-traffic areas such as schools, transit hubs, and public spaces. This project focuses on developing a robust and cost-effective footstep power generation system utilizing a connecting rod and crank mechanism combined with spur gears to optimize energy conversion.

This introduction provides the foundation for exploring the project's objectives, methodology, and significance in addressing energy sustainability challenges.

BLOCK DIAGRAM

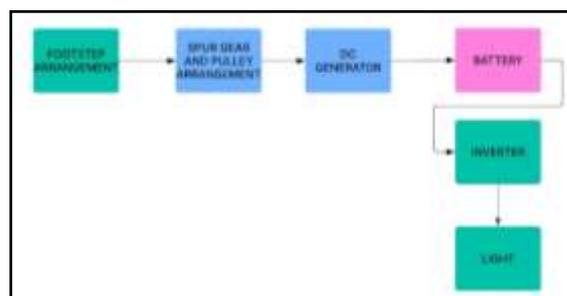


Fig: Block Diagram

2. WORKING PRINCIPLE:

The working principle of the footstep power generation system is based on converting mechanical energy from human footsteps into electrical energy. When a person steps on the system, the applied force moves the upper plate downward, causing a crank and connecting rod mechanism to convert the linear motion into rotary motion. Spur gears then amplify the rotational speed, which drives a low-RPM dynamo. The dynamo converts this mechanical energy into electrical energy, which is then regulated and stored in a battery. This stored energy can be used to power small electrical devices, such as LED lights.

- **Mechanical Energy Conversion:**
When a person steps on the system, the applied force causes the upper plate to move downward.
- **Crank and Connecting Rod Mechanism:**
The downward motion activates a crank and connecting rod mechanism, converting linear motion into rotary motion.
- **Role of Spur Gears:**
Spur gears amplify the rotational speed, increasing torque and ensuring efficient energy transfer.
- **Energy Conversion with Dynamo:**
The rotary motion drives a low-RPM dynamo, converting the mechanical energy into electrical energy.
- **Energy Regulation and Storage:**
The generated electrical energy is regulated and stored in a battery for later use.
- **Power Output:**
The stored energy can be used to power small electrical devices, such as LED lights or other low-power applications.

This system efficiently captures and converts kinetic energy from footsteps into usable electrical energy, offering a

sustainable solution for powering small devices.



3. Literature-Review:

“Power Generation in Automobile Suspension System” by C. Nithiyesh Kumar, K.Gowtham, M.Manikandan, P.Bharathkanna, T. Manoj Kumar

In this research paper author studied three methods of foot step power generation namely piezoelectric method, rack and pinion method and fuel piston method comparatively and found that the rack and pinion mechanism is more efficient with moderate cost of operation and maintenance. [1]

“Generation of Electrical Energy from Foot Step Using Rack and Pinion Mechanism” by Md.Azhar, Zitender Raj purohit, Abdul Saif, Nalla Abhinay, P.Sai Chandu

In this research paper authors used regulated 5V power, 500mA power supply. Bridge type full wave rectifier is used to rectify the ac output of secondary of 230/12V step down transformer. A rack and pinion is a type of linear actuator including a pair of gears which convert rotational motion into linear motion. The “pinion” engages teeth on the rack. In this paper, since the power generation using foot step get its energy requirements from Non-renewable source of energy. There is no need of power from external sources (mains) and there is less pollution in this source of energy. It is very useful to the places like all roads and as well as all kind of foot step which is used to generate the non-conventional energy like electricity. [2]

“Electrical Power Generation Using Foot Step for Urban Area Energy Applications” by Joydev Ghosh, Amit Saha, Samir Basak, Supratim Sen.

In this research paper authors used 80 volts and 40 mA from one coil have been generated from a prototype model as first invention. The second invention provides 95 volts and 50 mA from one coil and this

generated power can be used to light LED array and to run DC fan after rectifying the AC or can charge batteries. For high efficiency in the axel of the second gear, they fitted a strong magnet vertically, so that when the gear will rotate due to human body weight the magnet also rotate. The magnet is placed in a loop type copper coil. When the magnet start rotating according to the Faraday's law of electromagnetic induction, there will be induced emf in the coil. [3]

“Power generation through step” by Vipin Kumar Yadav¹, Vivek Kumar Yadav¹, Rajat Kumar¹, Ajay Yadav

In these research paper authors used equipment with following specification: Motor Voltage:10 volt Type: D.C. Generator, RPM:1000 rpm, Gear 1-Mild Steel, No. of teeth:59(big gear),No. of teeth:36(small gear),Type: Spur Gear, No. of gear used:2 Spring 1- Load bearing capacity:60-90 kg, Mild Steel, Total displacement:5 inch, Bearing 1- Type: Ball bearing, Bearing no.N35,Shaft 1- Diameter: 15 mm- Material: Mild steel author concluded that with these method energy conversion is simple efficient and pollution free. [4]

“Power Generation Footstep” by Shiraz Afzal, Farrukh hafeez

This paper is all about generating electricity when people walk on the Floor if we are able to design a power generating floor that can produce 100W on just 12 steps, then for 120 steps we can produce 1000 Watt and if we install such type of 100 floors with this system then it can produce 1MegaWattAs a fact only 11% of renewable energy contributes to our primary energy. If this project is deployed, then not only we can overcome the energy crises problem but this also contributes to create a healthy global environmental change. In this project a gear system is attached with flywheel which causes to rotate the dynamo as the tile on the deck is pressed The power that is created is saved in the batteries in addition we will be able to monitor and control the amount of electricity generated When an individual passes it push the tile on the ground surface which turn the shaft beneath the tile, turn is limited by clutch bearing which is underpinned by holders. Primary shaft is rotate 215approx... Twice by a single tile push. The movement of the prevailing shaft turn the gearbox shaft

which builds it 15 times (1:15) then its movement is smoothen by the help of fly wheel which temporary store the movement, which is convey to the DC generator (it generates 12V 40 amp at 1000 rpm). [5]

“POWER GENERATION FROM STEPS” by Ramesh Raja R, Sherin Mathew

This research paper attempts to show how energy can be tapped and used at a commonly used floor step. The usage of steps in every building is increasing day by day, since even every small building has some floors. A large amount of energy is wasted when we are International Journal of Engineering Applied Sciences and Technology, 2019 Vol. 4, Issue 05, ISSN No. 2455-2143, Pages 214-222 For Publishing Online September 2019 in IJEAST (<http://www.ijeast.com>) 216 stepping on the floors by the dissipation of heat and friction, every time a man steps up using stairs. There is great possibility of tapping this energy and generating power by making every staircase as a power generation unit. The generated power can be stored by batteries, and it will be used for slighting the building. [6]

“Electricity Generation from Footsteps; A Regenerative Energy Resource” by Tom Jose V*, Binoy Boban*, Sijo M T*

In these research paper author manufactured a model made from stainless steel, recycled car tires and recycled aluminum, also includes a lamp embedded in the pavement that lights up every time a step is converted into energy (using only 5 percent of the generated energy). The average square of pavement produces about 2.1 watts of electricity. And according to author, any one square of pavement in a high-foot traffic area can see 50,000 steps a day. Based on this data, only five units of pavement can be enough to keep the lights on at a bus stop all night. [7]

Future Scope

- Integration with **IoT** for energy management in smart cities.
- Advancements in **materials** to enhance efficiency and reduce costs.
- Large-scale applications for public infrastructure.

4. Methodology Overview

The project involves the integration of mechanical and electrical components to achieve energy conversion. The linear motion of footsteps is converted into rotary motion using a connecting rod and crank mechanism. Spur gears are employed to enhance torque and speed, while a dynamo converts the mechanical energy into electrical energy. The output is regulated and stored in a battery for later use. The system undergoes rigorous testing to assess its performance under different conditions.

4.1 System Design

The proposed system consists of the following key components:

- **Connecting Rod and Crank Mechanism:** Converts the linear motion of footsteps into rotary motion.
- **Spur Gears:** Amplify rotational speed and torque to enhance energy conversion efficiency.
- **Low-RPM Dynamo:** Converts mechanical energy into electrical energy.
- **Battery Storage System:** Stores the generated electricity for off-grid applications.

The system is designed to be scalable, allowing for deployment in high-traffic areas such as schools, transit hubs, and malls.

4.2 Fabrication-and-Assembly

The system was fabricated using durable materials to ensure longevity and reliability. The connecting rod and crank mechanism was constructed from high-strength steel, while the spur gears were precision-engineered to minimize energy loss. The low-RPM dynamo was selected for its efficiency in converting mechanical energy into electrical energy at low rotational speeds. The entire system was assembled with careful attention to gear alignment and mechanical stability.

5. Performance Evaluation

The system was subjected to rigorous testing to evaluate its performance. Key metrics included:

- **Voltage Output:** The system generates 3V per footstep, sufficient to power four 1.5V LED lights.
- **Energy Storage Capacity:** Assessed by monitoring the battery charge over time.
- **Gear Ratio Efficiency:** Calculated based on the rotational speed and torque output.

5.1 Analysis

Let us consider,
Height of foot step=80 Kg (Approximately)
12 cm

$$\therefore \text{Work done} = \text{Force} \times \text{Distance}$$

Here,

$$\text{Force} = \text{Weight of the Body}$$

$$= 80 \text{ Kg} \times 9.81$$

$$= 784.8 \text{ N}$$

Distance traveled by the body = Height of the foot step

$$= 12 \text{ cm}$$

$$= 0.12 \text{ m}$$

$$\therefore \text{Output power} = \text{Work done/Sec}$$

$$= (7848 \times 0.12)/60$$

$$= 1.56 \text{ Watts}$$

(For One pushing force)

$$\text{Watt} = \text{volt} \times \text{current}$$

Motor max output current is 250mA

Therefore,

$$\text{Watt} = \text{volt} \times 0.25$$

$$\text{By this we get voltage} = 1.56/0.25$$

$$= 2.08 \text{ volts approx.}$$

This may vary according to how fast the force is applied.

Now, let us calculate with the specs of motor

* Motor specs:-Output Voltage: 12V

Speed: 300RPM

Max. No Load Current: 60mA

Max. Load Current: 250mA

Total motor power = $V_{out} \times I_{out}$

$$= 12V \times 0.25A$$

$$= 6 \text{ watt}$$

$$300 \text{ rpm} = 6 \text{ watt}$$

$$\text{Each watt} = 6/300$$

$$= 2 \text{ volt}$$

Hence, in one revolution of the motor 2 volts will be generated.

However, with this much power produced, it cannot be tapped fully. For the above purpose, we have selected to generate electricity by permanent magnet type D.C generator and store it by 12V lead-acid battery cell.

The results demonstrated that the system was capable of generating sufficient electricity to power small off-grid applications, with potential for scalability in high-traffic environments.

6. Problem Definition

The following issues highlight the need for a footstep power generation system:

- **Wasted Kinetic Energy:** High-traffic areas such as railway stations, schools, malls, and airports generate significant kinetic energy from footsteps, which is currently unutilized.
- **Limitations of Existing Renewable Systems:** Solar and wind energy solutions are not always feasible in indoor or dense urban environments.
- **High Costs of Advanced Technologies:** Piezoelectric energy harvesting systems are expensive to manufacture and difficult to implement on a large scale.
- **Energy Demand and Sustainability:** The growing demand for electricity and the depletion of fossil fuel reserves necessitate the exploration of

alternative and sustainable energy sources.

- **Lack of Scalable Solutions:** Current energy harvesting technologies are often not designed for scalability and widespread deployment in high-traffic areas.

7.Challenges-and-Solutions

Several challenges were encountered during the design and fabrication process, including material durability, energy loss, and precise gear alignment. These challenges were addressed through the use of high-strength materials, precision engineering, and careful assembly techniques.

8. Result

In one revolution of the motor, 2V is generated. However, due to losses and inefficiencies, the full potential of this power cannot be utilized directly. To optimize power generation and storage, we have selected a permanent magnet DC generator for electricity generation. The generated voltage will be efficiently regulated and stored in a 12V lead-acid battery, ensuring a stable and reliable power supply for further applications

9.Conclusion

The design and fabrication of a footstep power generation system using a connecting rod and crank mechanism, spur gears, and a low-RPM dynamo has been successfully demonstrated. The system offers a durable and cost-effective alternative to piezoelectric systems, with potential for deployment in high-traffic areas. By harnessing wasted kinetic energy, this system contributes to the development of practical and sustainable renewable energy solutions.

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