International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 08 | Aug 2024 www.irjet.net p-ISSN: 2395-0072

Design and Analysis of Power Generation System Using Human Footsteps

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Abstract - *This project is all about creating a cool system that turns human footsteps into electricity! Electricity, as you know, is super important and we're using more of it every day, especially with more people around. While renewable sources like solar and wind energy are great, they have some limits. Did you know that an average person takes about 3,000 to 5,000 steps? It's true! Locations like malls and airports always have long lines. So, why not put a footstep power system at these places? As people step onto it, we can generate electricity. This energy will be produced every day. Our project combines the piezoelectric effect with the Rack & Pinion mechanism.*

Key Words: **Piezoelectric Effect, Rack and Pinion Mechanism, Power Generation, Non-Conventional Energy, Static Structural Analysis, Deformation.**

1. INTRODUCTION

Walking is one of the most essential things we do! And electricity? It's the energy we rely on the most. As our population grows and technology advances, our need for electricity keeps increasing. There are so many ways to generate power like solar systems using sunlight, wind turbines using breezes, or hydropower plants too! Yet these renewable options have their downsides. That makes it crucial to explore other solutions for generating electricity. One fun idea is making a system that captures energy from human footsteps.

Believe it or not, energy plays a significant role in our daily lives. Our lifestyle depends on having enough energy available to keep everything running smoothly. So understanding how we get energy and how it changes form is quite important! With awareness growing about the limits of our planet's energy resources, countries are starting to rethink how they manage energy use and cut down on waste.

When we walk, it's easy to overlook the force we're exerting—it often goes to waste! This project aims to capture that kinetic energy and turn it into electric power. Remember pedal power? It's been around since the 1800s! A gearbox can connect to a flywheel to make a dynamo spin [1]. We can whip up around 1,000 watts from just 120-150 steps! When people step down, their force transforms into mechanical energy thanks to the rack & pinion setup that helps generate electricity via a DC Generator [2].

In work by Saranya G. et al., they demonstrated how human movements on piezoelectric sensors create electric power. The sensors compress and produce kinetic energy that shifts into electrical form [3]. Also, an RFID (Radio Frequency Identification) system allows only authorized users to utilize this charging mechanism [4]. Another paper by Shivani Mahesh Pandit and team examined systems that not only generate & store energy but allow for monitoring too [5]. Imagine having this Wi-Fi-connected IoT system showing real-time voltage data [6]! Piezoelectric sensors can be set up in various combinations—series or parallel—to yield maximum voltage [7].

Using data from Bangladesh's population density shows how piezoelectric materials can generate energy effectively; one study noted that with just 12 piezoelectric sensors occupying one square foot and someone weighing 50 kg stepping down—each step could yield at least 1 volt [10].

1.1 Objectives of the project

- Create an innovative non-conventional energy source and spread the word
- Cut back heavy reliance on traditional energy sources
- Store generated electricity for future use
- Aim for cost-effective electricity production
- Provide accessible electricity in rural areas

1.2 Need for the system

- Populated areas should tap into wasted footsteps for extra energy
- Generated electricity can help local needs
- It has potential large-scale community benefits while also promoting better health through active participation
- Many similar systems could arise that tap into wasted footstep energy

2. MAKING OF FOOTSTEP POWER GENERATION MODEL

2.1 Components of the model

1. Rack Gear:

Rack gears are used to change over pivoting development into straight movement. A stuff rack has straight teeth cut into one surface of a square or round segment of bar and works with a pinion, which is a little tube-shaped gear fitting with the stuff rack. By and large, gear rack and pinion are all in all called "rack and pinion". There are numerous ways of using gears. As a mechanical component to move to turn into direct movement, gear racks are frequently contrasted with ball screws. The use of racks in place of ball screws has advantages and disadvantages. The upsides of a stuff rack are its mechanical effortlessness, enormous burden conveying limit, and no restriction to the length, and so forth. The backlash, on the other hand, is a drawback. A ball screw has high precision and lower backlash, but its limitation in length due to deflection is one of its drawbacks.

Fig.-1: Rack gear

2. Pinion Gear:

A pinion is a round gear generally the more modest of two fit gears utilized in a few applications, including drivetrain and rack and pinion frameworks.

Fig.-2: Pinion Gear

3. Piezoelectric Sensors:

A device known as a piezoelectric sensor converts changes in pressure, acceleration, temperature, strain, or force into an electrical charge to measure them. In a combination of parallel and series, two sets of three piezoelectrics that are connected in series will be attached.

4. Springs:

A spring is portrayed as a flexible body, whose limit is to contort when stacked and to recover its special shape when weight is removed. There are many different kinds of springs, but in this case, we used a helical compression spring with four springs because that was what we needed.

5. DC Generator:

Dynamo changes over mechanical revolution into electric power. A gadget transforms direct flow into electric power utilizing electromagnetism. It deals with Faraday's regulation. The dynamo utilizes a turning twist of wire and appealing fields to change over mechanical upset into beating direct current.

6. Battery:

An electric battery is a gadget comprising at least one electromechanical cell that converts synthetic energy into electrical energy. There is a positive or cathode terminal and a negative or anode terminal in each cell. Detail of battery:

- Battery limit is 12 1.3Ah.
- This is a chargeable one.
- Battery charging time 20 min.
- Working hours of two hours

2.2 3D SolidWorks Design of the model

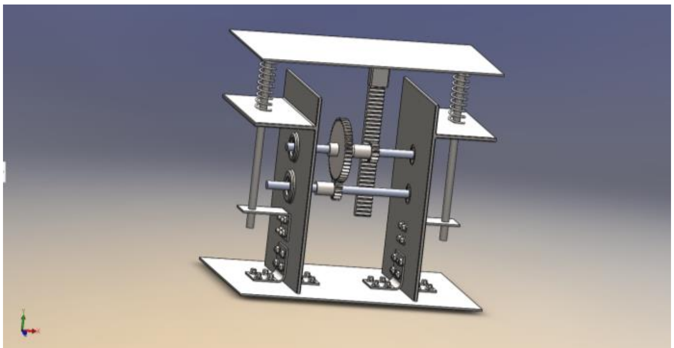

Fig.-3: 3D Design in SolidWorks

This plan is made utilizing SolidWorks Programming. Many orders like square shape, line, and so forth were utilized. Making a 3D model of the framework in SolidWorks is a significant piece of the venture, creating all system components. Gathering of the relative multitude of parts in SolidWorks with the appropriate aspects will be done.

Fig.-4: Image of the actual model

2.3 Connection of Piezoelectric Sensors

The piezoelectric transducer will be associated in series and equal association. Prior to utilizing the piezoelectric transducer to create electric energy, the association was not set in stone to pick the improved result from the piezoelectric transducer. The figure depicts three series-connected piezoelectric transducers. Two arrangements of three piezoelectric that are associated in series are appended in lined up for series-equal association The multimeter is associated with the piezoelectric transducers to quantify the voltage and flow across the association.

2.4 Working Principle of the Model

At the point when power is applied to the plate, the spring gets packed. The Rack here drops upward down. This outcome in a pivot of the pinion gear coincided with the rack gear. The pinion moves one full circle for each full compression. At the point when power gets let out of the plate, the pinion turns 1 round trip in the opposite course. This causes a pivot of stuff matches (gears An and B). The upper plate's piezoelectric sensor tile will also be subjected to simultaneous force. The generator associated with the last stuff and Power applied on a piezoelectric tile brings about the power age. As a result, this system will generate power in both directions. An AC-DC converter bridge connects the generator's output to a 12 V lead acid battery. This Battery will store the generated energy. Step Counts and generated voltage will be displayed on an LED Display connected to it.

3. TECHNICAL ANALYSIS

1. Spec details for gears:

Parameters	Rack Gear	Pinion Gear/ Spur Gear
No. of Teeth	35	25
Pressure Angle	20 Degrees	20 Degrees
Pitch Diameter	-	50 mm
Addendum Circle Diameter	-	57 mm
Dedendum Circle Diameter	-	47 mm
Length	350 mm	-

2. Battery specifications:

Lead Acid Battery recharge rating stands at twelve volts along with one amp-hour capacity (12V & 1.3 Amp).

3. Charging Time:

The produced energy is applied to the footsteps and stored in a storage device called BATTERY. So, it is taken as an essential phenomenon to determine the charging time taken by the battery. In this project, the battery is used with a battery rating of 1.3AH (ampere hour).

Charging Time=Battery Rating/Charging Current

4. Battery Backup Time:

Battery Backup Time=Battery Rating/Load Applied

5 Theoretical Power Output:

To calculate the power generated theoretically, it is important to determine the force exerted on the model. Let the force applied be calculated as,

Force = m.g
Work done =Force x Displacement
Power= Work done/Sec

Let the load applied by the body be 50kgs, then we can consider the maximum displacement of the spring as 0.05m Then we get,

Force =50 x 9.81=490.5N
Work done =490.5 x 0.05 i.e., work done = 24.525 J
Power=24.525\60 i.e., power =0.4087 J/s

Power generated per hour = 0.4087 x 3600 = 1471.5 Watts

6 Practical Power output:

Power can be calculated in terms of obtained voltage and current when the load is applied to the footsteps. The readings are noted by using the Multimeter.

Power = Voltage x Current

Here, when the foot is depressed due to the applied load on the footsteps the calculated power is as follows.
Let us assume, for one step of 20kg of load applied on the footsteps, the generated voltage is 2.6V and the average current produced is 12 milliamps. Then,

Power generated = 2.6 x 0.012 = 0.0312
Power generated per hour is 0.0312 x 3600 = 112.3 watts.

Thus, the obtained power for continuous load applied on the footsteps for 1 hour is **112.3 watts.**

7 Analysis of the model:

A static structural analysis decides the relocations, stresses, deformations, strains, and powers in designs or parts brought about by loads that don't prompt huge latency and damping impacts.
It is essential to know how much distortion is on the top plate when the particular burden is applied. For this reason, the static structural analysis is acted in the Ansys, by taking into account the typical load of a person for example 60 Kg

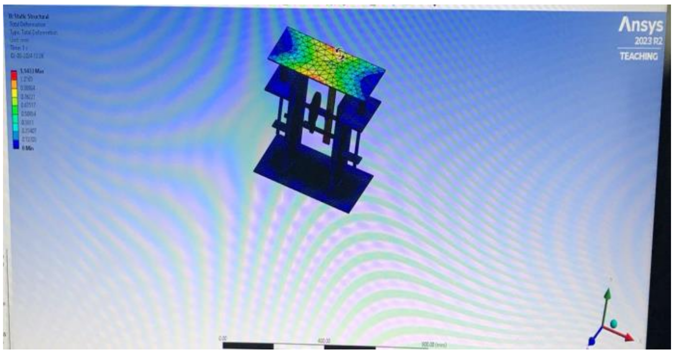

Fig.-5: Total deformation for the load of 60 Kg

The maximum total deformation we get is 1.1433 mm and The minimum total deformation we get is 0 mm.

4. CONCLUSION

This project is the most efficient and reasonable energy answer for everyday citizens. This can be utilized for the overwhelming majority of applications in country regions where power accessibility is extremely low or missing.

By utilizing this model, we can drive D.C. loads. It is particularly appropriate for use in jam-packed regions. This can be utilized in road lighting, as a charging port, and lighting for asphalt side structures.

In the event that this system is conveyed then not just, we can defeat the energy emergency issue yet this likewise add to making a solid worldwide natural change. It is a shrewd and solid framework and produces up to 2000W of power

A piezoelectric tile is equipped to produce more voltage when a more drawn-out time is taken. Subsequently, power will be produced in both the ways from rack and pinion system and piezoelectric sensors tile on the top. This power can be easily stored in the battery.

5. ACKNOWLEDGEMENT

I would like to recognize and say thanks to Prof. Mr. Vijay Bhosale and Dr. Ajay Gangrade, Department of Mechanical Engineering, KJSCE whose capable direction, excitement, imaginative thoughts, apathetic tolerance, shrewd remarks, and criticism were useful in the finish of our paper.

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