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Foot Step Power Generation-Power Generating Slabs

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Abstract: *In the world of modern technology, newer sources of energy and new methods of power generation are two important area of interest for researchers and engineers. A piezoelectric sensor based costly product is available in some developed countries which can generate power from human locomotive force, but it is not suitable for countries where power demand is very high but economy is not highly developed. This can be achieved by power generating slabs, which is used to generate power by establishing anywhere of the walking zone of human. This is done in a low cost process with locally available equipments. These slabs can easily sustain human weight when people walk along them. With a small deformation of spring, the weight of a human body is converted into electrical energy by rotating a micro-generator with the help of a `rotating shaft' coupled with it. This energy is stored in a rechargeable battery which can be used as a power source to drive loads. A power generating slab using mechanical parts consisting of Top plane, Rack and Pinion arrangement, Gear mechanism, springs, Shaft and Freewheeling bearing is designed. The power from dynamo is fed to electrical system consisting of Converter, battery and Inverter units which can be used for emergency backup power, charging purpose and to run small electrical equipments during load shedding conditions.*
Keywords - *Electrical energy, mechanical energy, power generating slabs, conversion circuits, load shedding*

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I. Introduction

Energy crisis is one of the major concerns in today's world. As the demand of energy is increasing everyday , the ultimate solution to deal with these sorts of problems is to implement renewable sources of energy A newer method, that are a lot less damaging, and does not threaten the environment have gained much interest in these years. Walking is the most common activity in day to day life. During the movement of a person, energy is lost in the form of impact or vibration on the walking surface, due to the transfer of this weight on to the road surface, through foot falls on the ground during every step. This energy can be tapped and converted into a usable form such as to electrical form. Lost energy conversion of human locomotive force into electrical energy is a relevant and important proposal of power production for highly populated countries of the world. This technology already exists in certain countries, where, piezoelectric sensors are used for this purpose. In a country like India, implementation of that technology is way too expensive in a wide scale and hence, a cheap alternative using mechanical alternative is used here. One such alternative is "FOOT STEP POWER GENERATION USING POWER GENERATING SLAB**"**. The method that has been implemented, to make power generating slab needs some simple mechanical set ups. It does not take more than a few footsteps to energize this module. This technology converts the linear kinetic energy applied during walking to displace a slab by a small length , and converts it into rotational energy to drive a motor. This particular slab, can be placed in footpaths at particular intervals, or even dance floors for a higher purpose, staircases etc. The amount of energy produced depends on the thrust, which depends on the weight of the person stepping on it. Here a prototype of power generating slab is designed and tested for simple light loads. This project will surely serve to be very helpful in the case where, renewable sources of non-polluting energy are required.

II. Methodology

Footstep arrangement is used to generate the electric power. As the power demand is increasing, this arrangement is used to generate the electrical power in order to meet the large energy demand. In this arrangement the mechanical energy is converted into electrical energy. When the pressure is applied on the top plane, the rack and pinion will convert mechanical energy into electrical energy. This electrical energy will be stored in a rechargeable battery connected to an inverter. In case of load shedding the power stored inside the battery is used to operate the light loads.

III. Components

Footstep power generation using power generating slabs, comprises of mechanical and electrical parts. The mechanical parts include a top plane, rack and pinion, springs, a shaft with freewheeling bearing, linear motion bearings and a flywheel. The electrical components employed in the prototype includes a dynamo, a converter unit, a battery, an inverter unit, an arduino UNO and the load. The dynamo is used to convert the rotational force into electrical output which is fed to the converter unit. The voltage is then stored to a rechargeable battery, which is afterwards supplied to the inverter unit. Here the DC voltage is converted to AC voltage and then given to a pre-programmed arduino UNO, which serves the purpose of switching.

3.1 Mechanical parts:
The mechanical parts mainly comprises of:
1) Top Plane
2) Rack and pinion
3) Springs
4) Shaft with freewheeling bearing
5) Linear motion bearing
6) Flywheel

3.1.1 Top plane
Top plane is the uppermost portion of the slab. The top plane is made up of iron. The primary function of this plate is to sustain the weight of the person walking over it. The footsteps will work as the mechanical force.
Specifications:
- Material – Iron
- Length - 90 cm
- Width - 30 cm

3.1.2 Rack and pinion
This part is attached with the top plane. The main function of this part is to convert the mechanical force (linear downward motion) exerted by the footsteps on the top plane into rotational force. The starting point of the rack is welded with the iron pate and the bottom is attached with a pinion along with a shaft.
Specifications:
- Length(rack) - 18 cm
- Width(pinion) - 3 cm

3.1.3 Springs
When a person walks along the slab the springs connected to the top plane is slightly distorted and when the load is removed they recover their original shape. This displacement does not make any discomfort in human walking zone.
Specifications:
- Spring type -Helical spring
- No of springs – 4
- Length – 3cm
- Range of weight tested – 50kg to 90kg
- Maximum displacement – 10mm/ 4 inches

3.1.4 Shaft with freewheeling bearing
A shaft is coupled with the pinion. The shaft is coupled between the iron frame works. The freewheeling type bearings are attached on the shaft.

Specificatons:
- length – 50 cm

3.1.5 Linear motion bearing
Linear motion bearing is a bearing designed to provide free motion in one direction. Linear motion bearing allows the downward linear motion of the top plane when a person walks along it.

Specifications:
- No of bearings – 4

3.1.6 Flywheel

A flywheel is a mechanical device used to store rotational energy. Flywheels can resist changes in rotational speed by means of their moment of inertia. The amount of energy stored in a flywheel is directly proportional to the square of its rotational speed. Flywheel helps to main the torque produced.

3.2 Electrical parts

The electrical parts comprises of:

1) Dynamo
2) Converter unit
3) Battery
4) Inverter unit
5) Arduino UNO

3.2.1 Dynamo

The dynamo used is a DC motor with a rating of 12V and 60 rpm as per design. The outer body of the gear head is made of high density plastic but it is quite easy to open because only screws are used to attach the outer and the inner structure. The major reason behind this could be to lubricate gear head from time to time. The plastic body contains a threading which enables the nut to be easily mounted and vice versa from the gear head. The rear view of the motor is similar to a DC motor and it has two wires soldered to it. The inside of plastic body comprises of gear assemblies, these are highly lubricated with grease to avoid any wear and tear caused by the frictional forces. It is connected to rotating shaft and has a gear that allows the rotation.

The dynamo is used to convert the rotational force from the rack and pinion system into electrical output which is fed to the converter unit for further stages. Planetary gear mechanism is used here. A heavy duty type gear mechanism using 3 mating gears to transmit torque to the output shaft is used here. This is suitable for limited space applications.

3.2.2 Converter unit

A buck boost converter unit is coupled with a rectifier. The rectifier used is a half wave rectifier.Rectificaton is provided to filter out any ripples in the output from the dynamo. Buck boost converter is being used to buck or boost the voltage to a required value. A voltage regulator is an electrical regulator which use an electromechanical mechanism, or passive or active electronic components to automatically maintain a constant voltage level.. Depending on the design, it may be used to regulate DC voltages. A 7812 regulator is used to maintain the voltage at 12V which is later fed to the battery. In this project value of inductor is taken as 3µH and capacitors are taken as 470µF and 1000µF.The switching frequency is 10kHz.

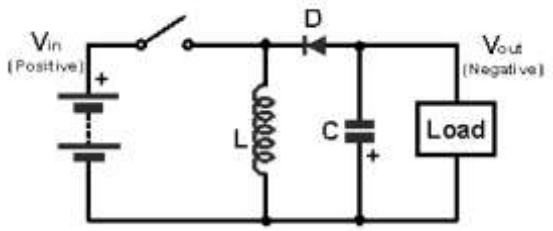

Fig 1. Converter Circuit

3.2.3 Battery

A 12 V battery is connected after the converter unit. The battery is used to store the energy produced by the converter unit. The battery used here is a rechargeable lead acid battery. The battery stores the power necessary to operate the light load during load shedding conditions.

3.2.4 Inverter

The main function of the inverter is to convert the DC stored in the battery to AC. The inverter circuit comprises of 2 MOSFET switches for switching as well as inverting purpose. The circuit also has a diode. Diodes allow electricity to flow in only one direction and also prevents the reverse flow of current from inverter to the battery. A LED is provided to make sure that the inverter circuit is working properly.

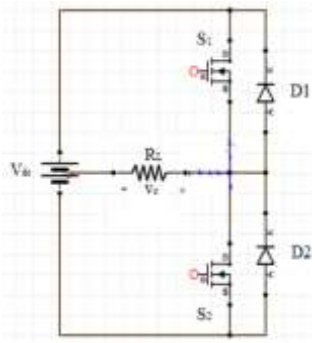

Fig 2. Inverter Circuit

3.2.5 Arduino UNO

The Arduino UNO is an open source microcontroller board based on the Microchip ATmega328P microcontroller, developed by Arduino. The board is equipped with sets of digital and analog input/output pins that may be interfaced to other circuits. The board comprises of 20 digital input/output pins(6 of which can be used as PWM outputs and 6 can be used as analog inputs), a USB connection, a power jack, an in-circuit system programming (ICSP) header, a reset button. Its operating voltage is 5V and DC ``Current per I/O Pin is 20 milliampere. The Arduino UNO has a number of facilities for communicating with the computer, another arduino board or other microcontrollers.

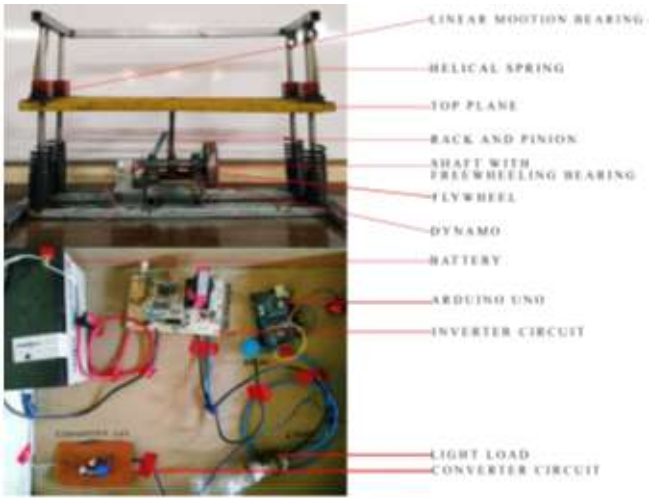

Fig 3. Complete prototype of hardware

IV. Block Diagram

When a person walks over the slab the top plane is displaced in the downward direction. This linear mechanical force is converted into rotational motion with the help of a rack and pinion mechanism and gear mechanism. This rotational mechanical force is then converted into electrical energy by means of a dynamo (DC motor). This electrical energy is then given to a converter unit. The converter unit comprises of a buck boost converter and a regulator. The converter unit converts AC to DC voltage and also regulates the voltage to a predetermined value. Next comes the battery which is used to store the energy which is used in the further stages. The output of a battery is then given to an inverter which converts DC to AC. The output from inverter is used to operate the light loads.

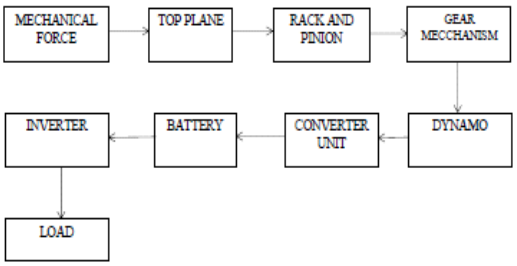

Fig. 4 Block Diagram

V. Working Principle

The mechanical power is converted into electrical energy by means of a dynamo. The rack & pinion, spring arrangement is fixed at the inclined step. The spring is used to return the inclined step in the same position when the load is released. Linear motion bearings are provided at the top plane. They provide free motion in one direction. Here we use a dc motor at the end of the shaft. Flywheel is provided at the other end of the shaft and is used to maintain the torque that has developed inside the system. They store torque and distort gradually. When mechanical force is applied on to the top plane, the plane undergoes linear displacement. Top plane is coupled with the rack and pinion arrangement. As the top plane moves downward, the pinion rotates. Pinion is coupled with the dc geared motor of 60 rpm. The motor converts small torque into many revolutions. The gear mechanism are used to amplify the motion. Linear movement is converted into rotational and the motor rotates. Voltage of range 12-18V is produced at the output of the motor. The motor is connected to a regulator circuit. It is used to regulate the voltage. Buck boost converter is incorporated along with regulator circuit to provide a constant power to battery. The generated power is stored in the battery. From the battery it is given to the inverter circuit. Relay is provided after inverter for protection purpose. The main objective of the project is to provide power to light loadings during load shedding period. Therefore an Arduino UNO is programmed so as to perform this function. Whenever main supply is off, the power from the battery is used to run the essential loads.

The circuit design of regulator fig (a), supporting circuit to provide pulse to the inverter fig(b) and inverter circuit fig(c) is shown below.

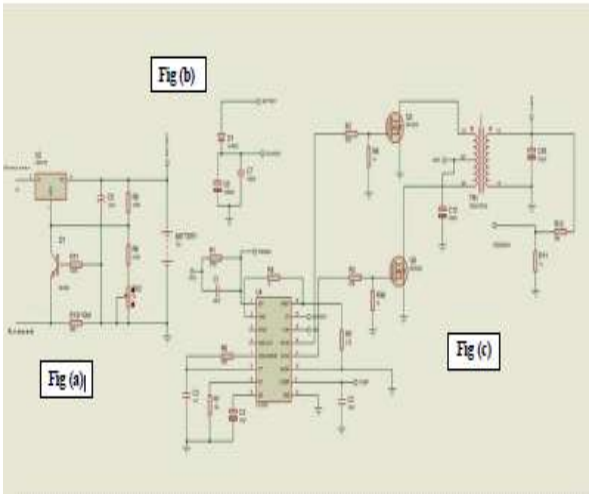

Fig 5. Electrical circuit

VI. Result

The power generated from the power generating slab can be stored using an energy storing device. The output of the generator is fed to a 12 V lead acid battery, through an AC-DC converter bridge. Initially, the battery was completely discharged. Then, the power generating slab was operated by applying foot load and energy was stored in the battery. A 100 W, 230V bulb was connected to the battery through an inverter at where 12V DC is stepped up to 230V AC.

The main objective of developing the power generating slab was to demonstrate the technology of harnessing energy from most common human activity i.e. walking. For producing more useable power. multiple unit clusters can be employed.

TABLE 1: RANGE OF WEIGHT AND RANGE OF VOLTAGE

RANGE OF WEIGHT (kg)	RANGE OF VOLTAGE (V)
50-90	6-18

VII. Advantages

Some of the advantages are, this technology is quite simple in nature, which is simple in both concept and in application. It can easily be implemented in many areas. Another advantage of this technology is that it is generating power without the use of any fuel. This with reduce the overall cost and the energy produced is clean in nature that is it causes no pollution. Another positive aspect of this system is that it is independent of the weather conditions unlike solar, wind and hydro power generation units. This system provides energy throughout the year. On comparison with the piezoelectric power generating unit , the cost of installation of this system is less thereby making it more economical to implement in under developed and developing countries.

VIII. Applications

• To run small electrical equipment during load shedding hours.
• Emergency backup power during blackout hours.
• Installment of this system along the sidewalks or pavement can harness a lot of power, this power can be used to light the street lights.
• Charging of devices.
• To power Led lights for specific purposes.
• Power air circulation system for rooms using small fans.
• This system can also be used in bus stands, car parking systems, airports, lifts etc.

IX. Conclusion

In modern world the demand of renewable energy is increasing rapidly. Power generating slab doesn't need any fuel to produce power. It just uses the energy that is lost by a human during walking. These slabs can be helpful in reducing power crisis. If these slabs are produced industrially and further research is done on materials and the design, the efficiency will be a lot better. Then these slabs can be viewed as a next promising source of generating power, especially in a country like India, where we have a lot of power crisis, and population explosion. Spreading this technology on large scale would be much cheaper and efficient than any other renewable sources of energy, and it should be highly recommended. This technology is completely harmless to life of any sort, and the environment, and highly beneficial, especially in our developing nation.

X. Future Scope

As for the future scope, we can use this principle in the speed breakers in highways where there is a lot of rush, thus the input torque and ultimate output of generator can be increased. If this technology is implemented in the stairs of a very busy building ,a lot of efficient electrical power can be harnessed to run the loads in the building. The approach for the utilization of waste energy by human locomotion is very relevant in highly populated countries like India and China where the roads, railway stations, bus stands, temples, etc. are all over crowded. This whole human locomotive energy being wasted, if can be made possible for utilization it will be a great invention and the crowd energy farms will be very useful energy sources in crowded countries. A large amount of electrical energy can be harnessed by such a technique and can be implemented to run necessary loads.

XI. Acknowledgement

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