Towards sustainable future: energy generation through footsteps

Rajeev Rathi[1*] Mahipal Singh[2]

[1,2]Associate professor, School of Mechanical Engineering, Lovely Professional University, Punjab, India - 144411

Corresponding author email- rathi.415@gmail.com

Abstract

Power and energy are two very important needs of humans in day-to-day life. With the increase in population, electrical energy consumption is increasing and the resources are depleting at a much faster rate. As most of resources are conventional in nature, so now a day the idea of electricity generation from renewable resources is growing around the globe. Energy generation from renewable energy resources is very costly and huge investment and time is needed to start the plant. To overcome this problem present study proposes a new approach for electricity generation through footstep. This is based on the concept of regeneration. This, a device is made to utilize the energy, which is wasted while walking. If this is compared to conventional systems, it is very useful, easily accessible and ecofriendly.

Keywords: Sustainability, Green Energy, Footsteps, Ecofriendly

1. Introduction

With the rise in consumption of the main non-renewable energy such as the fossil fuel, the world is experiencing energy crisis as these non-renewable energies will deplete and vanish accordingly within a few decades minimum or a few centuries maximum. To overcome the issues of increased energy prices and carbon emissions, most of the government agencies and technical companies are focusing on use of non-conventional resources for power generation [1]. For this purpose, solar panels, wind turbines and hydro power plants are used to produce electrical energy. But there is a need to come up with new ideas to harvest energy from our day-to-day activities. When a person steps on road, his body weight is transferred on the road and this cause waste of energy in the form of heat, friction and sound. In order to use and convert this energy into useful form, we have made an electricity-harvesting device. When a pedestrian over it, the weight of the person causes the downward movement of the top plate. This linear movement of plate is converted into rotational motion with help of rack and pinion combination and then used to rotate the shaft of the dynamo. The generated electricity will be stored in a battery and can be used to lighting the building [2]. When the device is overcrowded, then more electricity will be produced. So this concept can be very beneficial, if it is embedded in crowded places where there is continuous movement such as railway platforms, city footpaths and shopping malls etc.

2. Literature Review

The usage of traditional power generation method such as burning of coal, wood, diesel (generators) etc. is continuously depleting our natural resources such as fossil fuels, which is the demand for power has exceed the supply due to the rising population. In addition to this the traditional methods cause pollution, encourage deforestation the consequences are global warming, power shortage like we are facing in Tamilnadu [3]. Non-conventional energy using foot step needs no fuel input power to generate the output of the electrical power. Since the power generation using footstep get its energy requirements from the Non-renewable source of energy. There is no need of power from the mains and there is less pollution in this source of energy. It is very useful in roads and as well as all kind of foot step which is used to generate the non-conventional energy like electricity. Foot step energy generation can be used at high ways where are rushes of the vehicles too much thus increase input torque and ultimate output of generator. If we used this project at very busy stairs palace, then can produce efficient useful electrical for large purposes. This is applicable in street light for LED light for specific purposes or in air circulation system for room by the small fans. With the increase in population, electrical energy consumption is increasing and the resources from which electricity is generated are depleting at a much faster rate. So, the idea of electricity generation from renewable resources is gaining interest among peoples for this a device is made to utilize the energy, which is wasted while working. The device is made of special rack and pinion arrangement and this will generate approximately 3.127 MW annually with a displacement range of 0.75-1.5 inch [4]. Even if the planet doubled the amount of solar and wind power available tomorrow, there would still be a shortage of clean electricity. So need to grab energy from wherever we can find it, which is why piezoelectricity is using to charge that gathers in solid materials like crystal and ceramic in response to strain has recently begun to pique the interest of entrepreneurs and scientists. One of the most popular uses for piezoelectricity in the past few years relies on road sand sidewalks. This present project deals with the generation of electricity through traffic pressure by placing piezoelectric generators on the roads the axial load of the traffic pressure deforms the generator and thus produces the electric energy as an output, which may use for the street lighting, and many more aspects. India is a developing country where energy management is a big challenge for huge population. Nowadays man has needed and used energy at an increasing rate for his sustenance and well-being ever since he came on the earth a few million years ago. Due to this a lot of energy resources have been exhausted and wasted [5]. So the Proposal for the utilization of waste energy of foot power with human locomotion is very much relevant and important for highly populated countries like India and China in future. We can connect a backup supply from grid so that in case of shortage of power we can charge the battery from the gird and next option is integrating the system with solar system and form a hybrid system such that the cost storage equipment is reduced and pure clean energy is produced with a high reliability. Generation of electrical energy through non-conventional way, when people walks on Floor there is some forces exerts these forces usually wastes during the walking during walking. So idea is to convert mechanical energy of footsteps that is exerted by person into electrical energy by using transducers that

is known as foot step power Generation System. In this power generating floor is used to interpret the kinetic energy into electrical power so a day's demand of electrical energy is increasing and energy crises became the root issue in all over the world and conventional sources will not be enough for total demand of electrical energy [6-8]. The energy which is going waste when human climb the stairs. This human energy is utilized and converted into electrical energy [9-10]. The power can be generated through stepping on the stairs, the generated power will be stored and can be used for domestic purpose. The way of energy generation is ecofriendly and nonhazardous to human. The waste energy supplied by human is utilized in this system.

3. Energy

In physics, energy is the property that must be transferred to an object in order to perform work on – or to heat – the object, and can be converted in form, but not created or destroyed. The SI unit of energy is the joule, which is the energy transferred to an object by the mechanical work of moving it a distance of 1 metre against a force of 1 newton [11-12]. Common energy forms include the kinetic energy of a moving object, the potential energy stored by an object's position in a force field (gravitational, electric or magnetic), the elastic energy stored by stretching solid objects, the chemical energy released when a fuel burns, the radiant energy carried by light, and the thermal energy due to an object's temperature.

Table 1: Forms of Energy

Type of energy	Description
Kinetic	(≥0), that of the motion of a body
Potential	that stored by an object's position in a force field (comprises many of the forms below)
Mechanical	the sum of (usually macroscopic) kinetic and potential energies
Electric	that from electric fields
Magnetic	that from magnetic fields
Gravitational	that from gravitational fields
Chemical	that of chemical bonds (and chemical reactions)
Ionization	that of binding an electron to its atom or molecule
Nuclear	that of binding nucleons to form the atomic nucleus (and nuclear reactions)
Chromo dynamic	that of binding quarks to form hadrons
Elastic	that of deformation of a material (or its container) exhibiting a restorative force
Mechanical wave	(≥0), that propagated by a deformational wave through an elastic material
Sound wave	(≥0), that propagated by a sound wave, a form of mechanical wave
Radiant	(≥0), that propagated by electromagnetic radiation, including light
Thermal	a microscopic, disordered equivalent of mechanical energy
Rest	(≥0) that equivalent to an object's rest mass

4. Energy: Sources

Conventional energy sources: Sources which cannot be compensated, once these are used (after their exploitation). Non-conventional energy sources: These sources are renewable or inexhaustible and do not cause environmental pollution [13-14]. Moreover, they do not require heavy expenditure.

A. Conventional Energy Sources

- Coal
- Petroleum and natural gases
- Nuclear Energy

B. Non- Conventional Energy sources

- Solar Energy
- Wind Energy
- Tidal Energy
- Geo Thermal Energy

Conventional energy resources

Coal

Coal is a major conventional energy sources. It was formed from the remains of the trees and ferns grew in swamps around 500 million year ago. The bacterial and chemical decomposition of such plant debris (which remained buried under water or clay) produced an intermediate product known as peat which is mainly cellulose $(C_6H_{10}O_5)_n$. Due to progressive decomposition by heat and pressure, the cellulose lost moisture H_2 and O_2 and got converted in to coal as per the given equation [15-17].

Petroleum and natural gases

Petroleum is a complex mixture of hydrocarbons, mostly alkanes and cycloalkanes. It occurs below the earth crust entrapped under rocky strata. In its crude form, the viscous black liquid is known as petroleum and a gas in contact with petroleum layer which flows naturally from oil wells is termed as natural gases. The composition of natural gas is a mixture of mainly methane, (95.0%), small amounts of ethane, propane and butane (3.6%) and traces of CO_2 (0.48%) and N_2 (1.92%). [18-19]. A liquid mixture of propane and butane can be obtained from natural gas or refinery gases at room temperature under a pressure of 3-5 atmosphere. This is stored and distributed in 40-100 liter capacity steel cylinders. The crude petroleum after being refined and purified, are available as petrol, diesel, kerosene, lubricating oil, plastic etc. for commercial and domestic use. In India, the oil deposits, are found at Ganga-Brahmaputra Valley, Bombay high, plains of Gujarat, Thar Desert of Rajasthan and area around Andaman Nicobar Islands. On the world basis, petroleum deposits are found at Saudi Arab, Iraq, Iran, Kuwait, USA, Mexico, Russia etc [20-21]. As per the current survey, it is found that world petroleum deposits are diminishing at a very faster rate. If preventive steps are not taken, the existing petroleum will be available maximum up to 40 years.

Fuel woods

The rural peoples require fuel wood or fire Wood for their day to day cooking which are obtained from natural forests and plantations. Due to rapid deforestation, the availability of fire wood or fuel wood becomes difficult [22-23]. This problem can be avoided by massive afforestation (plantation) on degraded forest land, culturable waste land, barren land grazing land etc.

Hydropower

Energy obtainable from water flow or water falling from a higher potential to lower potential, is known is hydro- power. It is a conventional and renewable form of energy which can be transmitted to long distance through cables and wires. In India, hydroelectric power is generated by a number of multipurpose river valley projects e.g. Hydro-power project Hirakud, Bhakra Nangal project, Narmada valley project, Nagarjun Sagar project, Sardar Sarovar project etc [24-25].

Nuclear energy

A small amount of radioactive substance (U^{235}) can produce a lot of energy through the process of nuclear fission. For example, one ton of uranium can provide energy which is much higher than three million tons of coal or 12 million barrels of oil. In order to obtain nuclear energy, nuclear reactors are required [26-27]. There are around 300 nuclear reactors all over the world. India has only four nuclear power stations (reactors). The nuclear energy can be used in production of electrical energy, as a fuel for marine vessel and space crafts and for the generation of heat in chemical processing plants. In India, Uranium deposits are found at different parts of Rajasthan and Singhbum of Jharkhand. Thorium is recovered from monazite sand found in the state of Kerala. Due to the higher energy releasing tendency of these radioactive substances, these can be used in nuclear reactors to release energy crisis [28-29]. But the radioactive substances are exhaustible and can be used to develop nuclear weapons of mass destruction. In addition, dumping or radioactive wastes cause serious environmental hazards.

Non-Conventional Energy Sources

Solar energy

Solar energy, a primary energy source, is non-polluting and inexhaustible.

There are three methods to harness solar energy

(i) Converting solar energy directly into electrical energy in solar power stations using photo cells or photovoltaic cells or silicon solar cell.

(ii) Using photosynthetic and biological process for energy trapping. In the process of photosynthesis, green plants absorb solar energy and convert it into chemical energy, stored in the form of carbohydrate [30-31].

(iii) Converting solar energy in to thermal energy by suitable devices which may be subsequently converted into mechanical, chemical or electrical energy. Since solar energy is non-ending and its conversion to some other energy form is nonpolluting, attention should be paid for the maximum utilization of solar energy.

Wind energy

Wind is air in motion. The movement of air takes place due to the convection current set out in the atmosphere which is again due to heating of earth's surface by solar radiation, rotation of earth etc. The movement of air occurs both horizontally and vertically. The average annual wind density is 3 kW/m^2/day along costal lines of Gujarat, western ghat central parts of India which may show a seasonal variation (i.e., in winter it may go up to 10kW/m^2/day). Since wind has a tremendous amount of energy, its energy can be converted into mechanical or electrical energy using suitable devices, now days, wind energy s converted in to electrical energy which is subsequently used for pumping water, grinding of corns etc. As per available data dearly 20,000 mW of electricity can be generated from wind [32-33]. In Puri, wind farms are set up which can generate 550 kW of electricity.

Tidal energy

The energy associated with the tides of the Ocean canbe converted in to electrical energy. France constructed the first tidal power plant in 1966. India could take up Ocean thermal energy conversion (OTEC) and by the process it will be capable of generating 50,000 mW of electricity, to meet the power requirements of remote oceanic islands and coastal towns. The Netherlands is famous for windmills. In India, Gujarat and Tamil nadu have windmills [18]. The largest wind farm has been set at Kanyakumari which generates 380 mW of electricity.

Geothermal energy

The geothermal energy may be defined as the heat energy obtainable from hot rocks present inside the earth crust. At the deeper region of earth crust, the solid rock gets melted in to magma, due to very high temperature. The magma layer is pushed up due to some geological changes and get concentrated below the earth crust [19]. The places of hot magma concentration at fairly less depth are known as hot spots. These hot spots are known as sources of geothermal energy. Now a days, efforts are being made to use this energy for generating power and creating refrigeration etc. There are a quite few number of methods of harnessing geothermal energy. Different sites of geothermal energy generation are Puga (Ladakh), Tattapani (Suraguja, M.P.), Cambay Basin (Alkananda Valley, Uttaranchal).

Bio-mass based energy

The organic matters originated from living organisms (plants and animals) like wood, cattle dung, sewage, agricultural wastes etc. are called as biomass. These substances can be burnt to produce heat energy which can be used in the generation of electricity [34]. Thus, the energy produced from the biomass is known as biomass energy.

5. Energy Demand in India

The primary energy consumption in India is the third biggest after China and USA with 5.3% global share in 2015 [21]. The total primary energy consumption from crude oil (195.5 Mtoe; 27.91%), natural gas (45.5 Mtoe; 6.50%), coal (407.2 Mtoe; 58.13%), nuclear energy (8.6 Mtoe; 1.23%), hydroelectricity (28.1 Mtoe; 4.01%)

and renewable power (15.5 Mtoe; 2.21%) is 700.5 Mtoe (excluding traditional biomass use) in 2015 [35]. In 2013, India's net imports are nearly 144.3 million tons of crude oil, 16 Mtoe of LNG and 95 Mtoe coal totaling to 255.3 Mtoe of primary energy which is equal to 42.9% of total primary energy consumption. About 70% of India's electricity generation capacity is from fossil fuels. India is largely dependent on fossil fuel imports to meet its energy demands - by 2030, India's dependence on energy imports is expected to exceed 53% of the country's total energy consumption. In 2014-15, the per-capita energy consumption is 17.731 Giga Joules (0.424 Mtoe) excluding traditional biomass use and the energy intensity of the Indian economy is 0.2129 Mega Joules per INR (51 kcal/INR) [36]. Due to rapid economic expansion, India has one of the world's fastest growing energy markets and is expected to be the second-largest contributor to the increase in global energy demand by 2035.

The installed capacity of utility power plants is 314.64 GW as on 31 January 2017 and the gross electricity generated by utilities during the year 2015-16 is 1168.359 billion kWh which includes auxiliary power consumption of power generating stations. The installed capacity of captive power plants in industries (1 MW and above) is 47,200 MW as on 31 March 2016 and generated 183.611 billion kWh in the financial year 2015-16 [37]. In addition, there are nearly 75,000 MW aggregate capacity diesel generator sets with unit's sizes between 100 KVA and 1000 KVA. All India per capita consumption of Electricity is nearly 1075 kWh during the financial year 2015-16.

Table 2: Installed Power Capacity

Sector	Power capacity (MW)	Share (%)
State units	10,2463.53	33.00
Central units	76,982.26	25.00
Private units	130,559.49	42.00
Total		310,005.28

Table 3: Rural Electrification: Status

Rural electrification rate	State/UT (Electrification rate, Un-electrified villages)
100%	20 states and 6 union territories
99.00-99.99%	Himachal Pradesh (99.81%, 34), Uttar Pradesh (99.77%, 224), Uttarakhand (99.52%, 76), Rajasthan (99.26%, 332), Madhya Pradesh (99.51%, 258), Karnataka (99.86%, 39), West Bengal (99.96%, 14)
95.00-98.99%	Jammu & Kashmir (98.31%, 107), Tripura (98.03%, 17), Bihar (97.46%, 993), Chhattisgarh (96.55%, 675), Odisha (95.33%, 2210)

90.00-94.99%	Jharkhand (93.98%, 1775), Assam (92.31%, 1950), Manipur (91.55%, 201), Mizoram (94.03%, 42), Nagaland (94.14%, 82)
80.00-89.99%	Meghalaya (85.9%, 42), Andaman & Nicobar Islands (86.11%)
Below 80%	Arunachal Pradesh (73.3%, 1404)

6. Energy Generation from footstep

Walking is the most common activity in day to day life. When a Person walks, he/she loses energy to the road surface in the form of impact, vibration, sound etc., due to the transfer of his weight on to the road surface, through foot falls on the ground during every step. This energy can be tapped and converted in the usable form such as electrical energy. In order to develop a technique to harness foot step energy, a foot step electricity generating device was developed. This device, if embedded in the footpath, can convert foot impact energy into electrical form. The working principle is simple. When a pedestrian step on the top plate of the device, the plate will dip down slightly due to the weight of the pedestrian. The downward movement of the plate results in rotation of the shaft of an electrical alternator, fitted in the device, to produce electrical energy [38-39]. The top plate reverts back to its original position due to negating spring provided in the device. The energy generated by this device can be stored in a 12v lead acid battery. A 100watt, 230volt bulb was connected to the battery through an inverter. The device was operated by persons walking over to it. The bulb automatically lights up when the battery reaches its full voltage. The bulb remained lighted till the battery was exhausted. However, if there is continuous movement of pedestrians over the device, the bulb can be kept lighted continuously. The power generated by the foot step generator can be stored in an energy storing device. The output of the generator was fed to a 12v lead acid battery [40]. Initially, the battery was completely discharged. Then the foot step electrical generator was operated by applying foot load and energy was stored in the battery. The top plate of this device is mounted with a shaft on which chain is welded (which acts like a rack) and spring. The links of chain are engaged with the teeth of sprocket (this mechanism acts like a rack and pinion arrangement) and sprocket shaft is connected to the dynamo shaft through a chain link mechanism. When a person steps on the top plate of the device, due to his body weight there will be a small downward displacement of the plate. When the person moves on and removes his step, due to the force of spring the plate is pushed back to its initial position. By using the special combination of Chain and sprocket (i.e. rack & pinion), the linear reciprocating motion is converted into rotational motion. The rotational motion of the sprocket shaft rotates the dynamo shaft and generates the voltage. For further use the voltage is stored in a capacitor.

Components Used

- Frame, Shaft , Dynamo, Sprocket and chain, Spring, and watt LED

Mechanism for energy generation

Rack and pinion system (i.e. chain and sprocket): A chain and sprocket is a type of linear actuator that comprises a pair of gears which convert rotational motion into linear motion. The circular sprocket engages teeth on a linear "chain". Rotational motion applied to the sprocket will cause the chain to move to the side, up to the limit of its travel. For example, in a rack railway, the rotation of a pinion mounted on a locomotive or a railcar engages a rack between the rails and pulls a train along a steep slope. The rack and pinion arrangement (i.e. chain and sprocket) is commonly found in the steering mechanism of cars or other wheeled, steered vehicles. This arrangement provides a lesser mechanical advantage than other mechanisms such as recirculating ball, but much less backlash and greater feedback, or steering "feel" The use of a variable rack (still using a normal sprocket) was invented by Arthur E Bishop, so as to improve vehicle response and steering "feel" especially at high speeds, and that has been fitted to many new vehicles, after he created a specialized version of a net-shape warm press forging process to manufacture the racks to their final form, thus eliminating any subsequent need to machine the gear teeth. For every pair of conjugate involute profile, there is a basic rack.

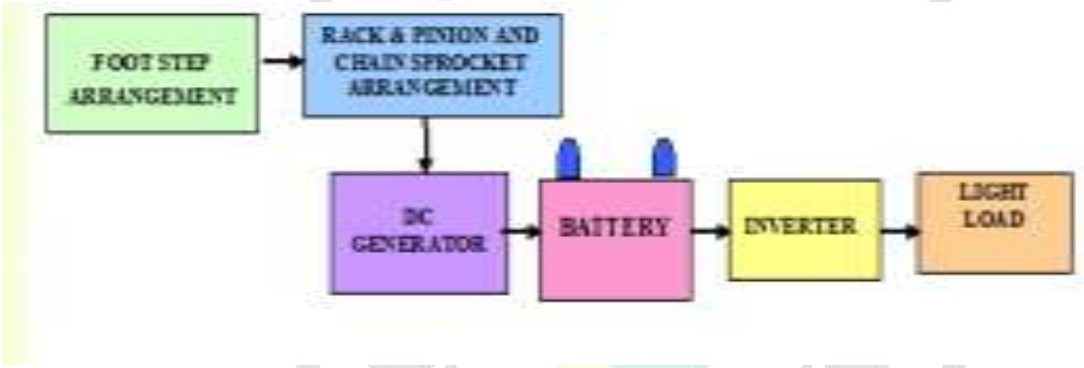

Figure 1: Circuit Diagram

This basic rack is the profile of the conjugate gear of infinite pitch radius. A generating rack is a rack outline used to indicate tooth details and dimensions for the design of a generating tool, such as a gear shaper cutter.

The complete diagram of the foot step power generation is given fig. only one step is inclined in certain small angle which is used to generate the power. The pushing power is converted into electrical energy by proper driving arrangement. The Chain & sprocket, spring arrangement is fixed at the inclined step. The spring is used to return the inclined step in same position by releasing the load. The pinion shaft is connected to the supporter by end bearings. As shown in fig. The larger sprocket also coupled with the pinion shaft, so that it is running the same speed of small sprocket to increase the number of rotation in dynamo. The larger sprocket is coupled to the small cycle sprocket with the help of chain (cycle). This larger sprocket is used to transfer the rotation force to the smaller sprocket. The complete block diagram is shown in fig.

1. Conclusions

During extensive literature review it is observed that, the research carried out are all related to energy harvesting device from human footsteps and scope of improvements. Design research methods like product study, market study, user study and ethnography helped in knowing the existing technology to harvest human footstep energy, who are the competitors. And it's understood that in India, there are no manufacturers of energy generation device from human footstep. Concept were generated by addressing the issues like safety, ergonomics, simplified mechanism, aesthetics and cost. Model making gave an opportunity to learn model making techniques, manufacturing process and difficulties involved, and linked the gap between, designer and engineer thoughts. Mock-up model developed, to understand the features and feasibilities of the product and user's feedback found satisfactory. Working prototype developed as a proof of concept to harvest energy from human footsteps. This statement of Albert Einstein is true "Energy can neither be created nor be destroyed it can be transferred from one form to another". In future aspects this principal can be used in speed breakers at high ways where rushes of the vehicles are too much thus increasing input torque and ultimate output of generator. This process can also be applicable at very busy stairs palaces where it produces huge amount electricity.

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