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Power Harvesting from Human Footstep in Crowded Area

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Abstract- The process of deriving or capturing the energy from a system's surrounding and converting it into exploitable electrical energy is termed as power harvesting. In the recent years, significant studies have been conducted in the arena of power harvesting. The purpose of this paper is to institute a simple and low cost rack and pinion mechanism that can be used to harvest power and improve the performance and effectiveness of energy conversion from kinetic energy to electrical energy using footsteps on a limited crowded area like the university campus. A total of 30 students of Southern university Bangladesh had participated in the experiment. The average power produced was 4.93 watt and the overall efficiency of proposed mode was 59.42%.

Keywords: Rack and pinion mechanism, forward power, reverse power, mechanical power.

1. INTRODUCTION

Human body is a recognized source of energy. An average-sized body of a grown human can store energy in fat as a 1000-kg standard battery. Humans use their body muscles in their activities; as a result, the stored chemical energy is converted into desired mechanical work. The maximum efficiencies of a human can be up to 25%. The human works can be accomplished at a elevated rate, where 100 W energy can be sustainable. Devices are being designed specially to convert human power to generate electricity, like, hand-crank generators, wind-up flashlights, radios, and phone chargers. In most of these equipments, power is being produced as the byproduct of other actions, naturally resulting short burst of power generation. For pursuing longer and sustainable power production, harvesting energy from general day to day activities such as walking, running, cycling or even dancing would be more advantageous [1].The prospect and the efficacy of extracting usable energy from human actions have been under research and study for years. It is observed that steady and continual power can potentially be achieved (figure 01): from typing (~mW), motion of upper limbs (~10 mW), air exhalation while breathing (~100 mW), walking (~W) [2]. Klimiec et al. demonstrated that the rear foot exerts the greater part of the pressure, i.e., almost one third of the complete foot pressure, when walking on the flat surface plane [3]. Furthermore, another study reported that no considerable differences were perceived when judged against plantar pressure distribution created by both feet of men and women on flat surfaces, entailing that the negligible impacts of gender factor [4].

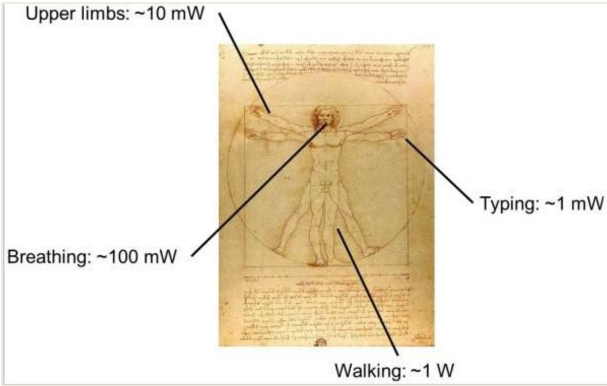

Fig. 01: Evaluation of obtainable power that can be harvested from wasted human actions [2]

The foundation of our project is to generate electricity by utilizing the human locomotive force of the people where it is usually crowded like the college, on the rising stairs of the university. We can use this power for domestic uses in lights, fans, and street light etc. by charging the battery at the emerging stairs or the sides walk [5]. The application of using extravagant energy in foots of human can be a rich source for extremely populated nations like Bangladesh, China and India. In these countries, offices, Schools, Colleges, Universities, bus stations are crowded and packed round the clock. For these places, producing such power can be availed and deployed by converting mechanical energy to electrical energy.

2. Materials and Methods

The physical model of foot step power generation module as shown in Fig.01 is made of a top wooden plate and a steel structure. There are four set of springs that are supports the weight of a subject. Number of steel rods has been used to stabilize the plate. The vertical movement of the subject plate is transformed to rotating motion by a rack and pinion. In the arrangement, two steps are considered. The rack & pinion and the spring arrangement is attached below the steps. Four springs has been used for each step. Spring tension is capable to return the step in same position by releasing the load. The rack is attached to the foot step.

During second step, the Rack gets connected to the footstep. From the rack a shaft is allocated in which the bigger sprocket lies. The bigger sprocket being coupled with the rack, results in running at the same speed of the rack. The bigger sprocket is also coupled with the smaller sprocket below in the other shaft with the help of spur gears (cycle). This bigger sprocket is responsible for transferring the rotation force to the smaller sprocket. A suitable gear is attached there also. The smaller sprocket runs in the same direction for the both the forward and reverse direction of rotation of the bigger sprocket with same speed.

This stated action looks like a Spur gear in pedaling action. The gear wheel provided in smaller sprocket is coupled with the DC Generator. The DC Generator capacity used in the experiment was 12V. From the DC Generator, the wires are attached and connected to LED for showing the harvested output power. Here the spur gear mechanism rotates only in single direction. The arrangement is made for the first step as the footsteps are directly connected to the Rack & pinion arrangement. To the pinion shaft DC Generator is attached and LED are coupled to it. Thus Mechanical energy is being converted into Electrical energy.

Fig. 1: Fabricated footstep floor module

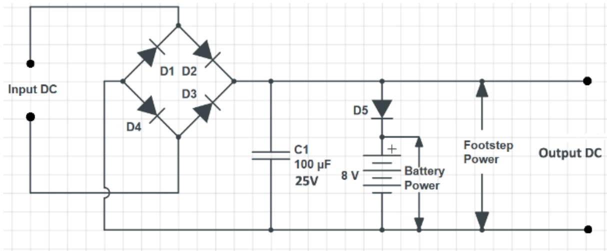

Fig. 2: Voltage optimization and regulation circuit used with the model

The simplest rectifier can be a diode bridge rectifier (Figure 02). The AC-DC converter can be followed by a DC-DC converter, for power optimization and voltage regulation. The produced voltage will vary with the load occurred by the person; more weight will be producing more power, so a constant must be supplied to the battery in order to charge the battery properly as well as enhancing its efficiency and life span. proposed circuit is designed to provide a constant 12v to the battery for a variable voltage between 10 to 30 volts. It also has an additional feature for monitoring the temperature of the battery. The feature monitors the temperature of the battery while charging and cut off the supply in case of rise in temperature beyond expected limit.

3. Specification: Mechanical components

C.Nithiyesh Kumar et al. completed the comparative study on four mechanisms: piezoelectric, rack and pinion, piston and roller. They showed that the rack and pinion mechanism could be made more proficient with moderate cost of operation and maintenance [5]. The study is a practical demonstration of the statement. The components used in the experiment are stated in table 1 and 2.

Table 1: Mechanical Component

Component Name	No of Quantity
a. Rack gear (linear)	1
b. Pinion (small size)	1
c. Spur gear	1
d. MS pipe	4
e. Compressing spring	4
f. Square box 25mm	8 fit
g. MS Sheet	(3 X 500 X 800) mm
h. Main shaft (20 mm x 800 mm)	1
i. Nut and bolt	8
j. Bearing	4
k. Block for bearing	2
l. Rod shaft	4

Table 2: Electrical Components

Component Name	No of Quantity
a. Diode (N4001)	4
b. Capacitor (25 v, 100 micro f...)	1
c. LED light	1
d. On - Off Switch	1
e. Battery	1
f. Terminal block	1
g. Dc Generator (12V, 100r.p.m)	2
h. Connecting wire	

4. RESULTS AND DISCUSSION

Table 3: Data collection of the project
(Average power / Vehicle power generation)

FOOT STEP	WEIGHT	Voltage		Current		Power	
		V (F) Volt	V (R) Volt	I (F) Amp	I (R) Amp	P (F) Watt	P (R) Watt
1	70	16	15	0.306	0.226	4.896	3.39
2	73	18	15	0.247	0.315	4.446	4.725
3	65	17	14.5	0.324	0.216	5.508	3.132
4	82	18	16	0.27	0.263	4.86	4.208
5	83	21	22	0.3	0.24	6.3	5.28
6	65	16	18	0.283	0.211	4.528	3.798
7	70	13	14	0.253	0.201	3.289	2.814
8	80	21	16	0.308	0.304	6.468	4.864
9	70	14	19	0.307	0.315	4.298	5.985
10	72	18	16	0.277	0.261	4.986	4.176
11	65	17	15	0.217	0.261	3.689	3.915
12	67	19	18	0.223	0.217	4.237	3.906
13	61	16	15	0.201	0.211	3.216	3.165
14	66	19	18	0.281	0.279	5.339	5.022
15	68	16	17	0.3	0.297	4.8	5.049
16	69	19	18	0.299	0.3	5.681	5.4
17	71	18	19	0.291	0.295	5.238	5.605
18	70	15	18	0.302	0.301	4.53	5.418
19	60	14	17	0.27	0.269	3.78	4.573
20	65	17	18	0.284	0.221	4.828	3.978
21	63	16	17	0.277	0.217	4.432	3.689
22	67	18	18	0.285	0.282	5.13	5.076
23	62	15	14	0.203	0.201	3.045	2.814
24	66	20	19	0.291	0.287	5.82	5.453
25	69	19	18	0.3	0.291	5.7	5.238
26	67	17	18	0.283	0.217	4.811	3.906
27	70	19	21	0.32	0.29	6.08	6.09
28	61	18	19	0.281	0.294	5.058	5.586
29	68	21	22	0.331	0.311	6.951	6.842
30	69	19	23	0.319	0.249	6.061	5.727
				Total power		148.005	138.824

4.1 Graphical representation

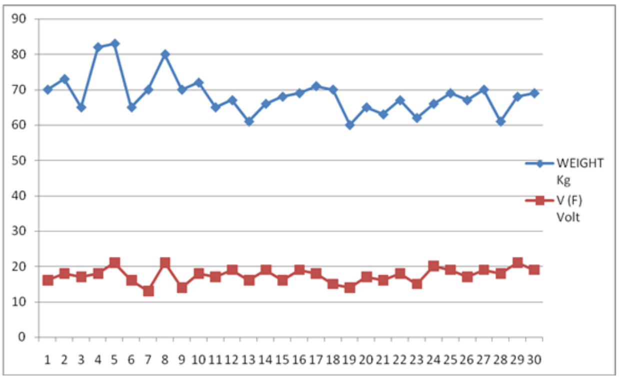

Fig. 3: Graphical representation weight and voltage forward vs footstep.

Figure 3 represents the graphical presentation of weight and voltage (forward) at a vehicle power generation system. The line blue color mentions the weight. Highest weight is 83 kg, lowest weight 60 kg and average weight is 68.47 kg. The line red color mentions the voltage forward. Highest voltage is 21 volts, lowest 14 average forward voltages 17.47 volt.

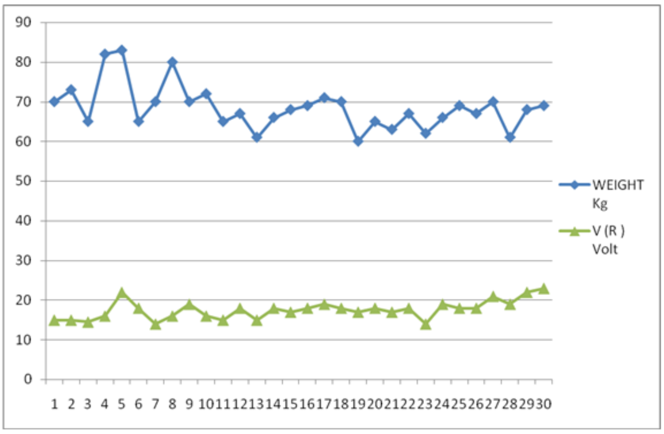

Fig. 4: Graphical representation weight and voltage reverse power.

Figure 4 represents the graphical representation weight and voltage revise at a vehicle power generation system. The line blue color mentions the weigh and green color mention the voltage. Highest weight is 83 kg, lowest weight 60 kg and average weight is 68.47 kg. The lines green color mentions the voltage revise. Highest voltage is 23 volts, lowest 14 average voltages 17.58 volt.

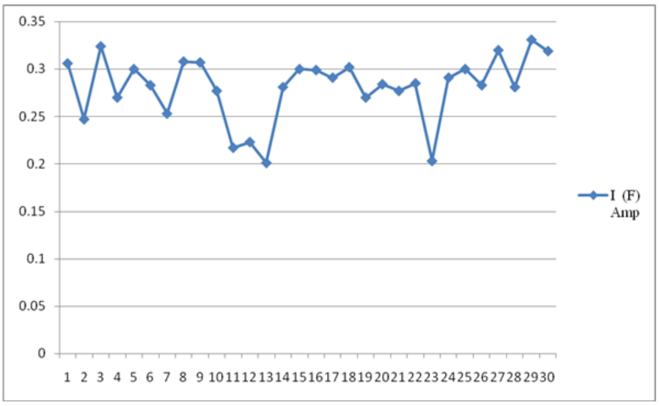

Fig. 5: Graphical representation of forward current.

Figure 5 represents the graphical representation of forward current has produced at a vehicle power generation system. The line blue color mentions the forward current against by weight. Highest forward current 0.331 amps for step 29 the weight is 68 kg. Lowest forward current 0.201 amps for step 13 the weight is 61 kg. The averages forward current 0.281 amps.

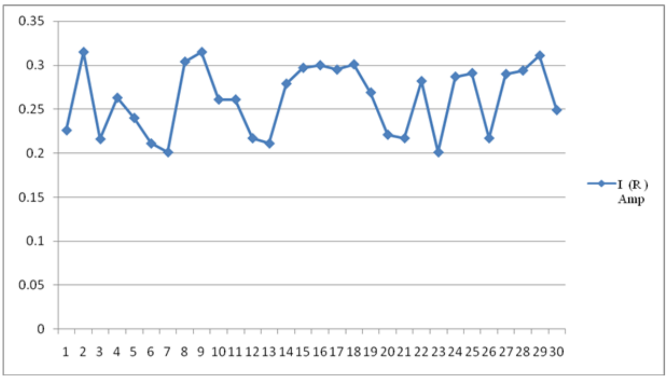

Fig. 6: Graphical representation of revise current.

Figure 6 represents the graphical representation of revise current has produced at a vehicle power generation system. The line blue color mentions the revise current against by weight. Highest revise current 0.315 amps for step 2 and step 9 the weight is 69 kg and 70 kg. The lowest revise current 0.201 amps for step 7 and step 23 the weight is 70 kg and 62 kg. The averages reverse current 0.261 amps.

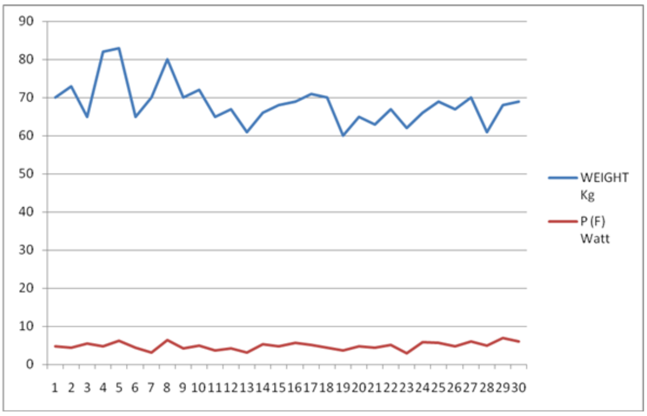

Fig. 7: Graphical representation weight and forward power vs footstep.

Figure 7 represents the graphical representation of forward power that has produced at a vehicle power generation system. The line blue color mentions the weigh and red color mention the power. Highest forward power is 6.951 watt for step 29 the weight is 68 kg. The lowest forward 3.045 watt for step 23 the weight 68 kg and forward voltage is 15 volts; forward current is 0.291 amps. The average forward power 4.93 watt.

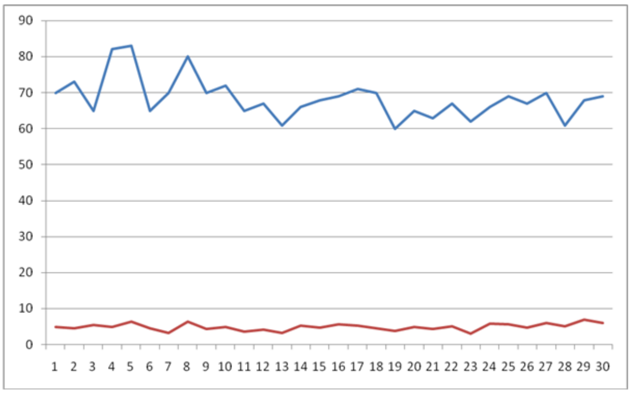

Fig. 8: Graphical representation weight and reverse power vs footstep

Figure 8 represents the graphical representation of forward current has produced at a vehicle power generation system. The line blue color mentions the revise power and red color mention the power. Highest revise power is 6.842 watt for step 29 the weight is 68 kg and revises voltage 22 volt and reverse current 0.311 amps. The lowest reverse power 2.814 watt for step 7 and step 23 the weight is 70 kg and 62 kg and revises voltage is 14 volts and 14 volts. Reverse current 0.201 amps and 0.201 amps. The average reverse power is 4.62 amps.

Average power = [Total average power/30]
= [148.005/30]
= 4.933 Watt/footstep

4. Performance calculation

Electrical Input;
We know that
E_P= m*g*h
= (61*9.81*0.0444)
= 26.56 J

m = Mass
g = gravity = 9.81 m/s^2
h = height
Here,
m = 61 kg&g = 9.81

Electrical Output;
E = [P * T]
= [Average power * (T (f) +T(r)]
= [4.933 (1.5 + 1.7)]
= 15.78

Here,
f = Forward,
r = Revise,

Time Forward (f) = 1.5 sec,

Time Revise (r) = 1.7 sec.

Efficiency;
Efficiency = (Output/Input) * 100
= (15.29/26.56) * 100
= 59.42%

6. CONCLUSION

The proposed experimental setup is certainly capable of risk free energy generation. The energy that is normally going to be wasted while performing certain actions are utilized and converted into electrical energy. It could be highly cost effective when continuously used. It can be installed in crowded areas such as universities, malls, bus stands, railway stations, school, colleges etc. The proposed method generates electric power without causing hazard to the environment. The unutilized and wasted energy produced by the crowd is reverted in this system. The source of energy remains uninterrupted and green as well as renewable when required. The proposed work “Power Harvesting from Human Footstep in crowded area” has been successfully tested and it is one of the best reasonable, inexpensive energy solutions to mass people. Small changes in construction and design of the power generation set up can help to increase the efficiency in future.

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