Power Generation through Gravitational Pull

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Abstract. The knowledge of utilizing the regularly lost energy in the surrounding of a system and changing over it into electrical energy that can be utilized to enhance the lifetime of that system's power supply or perhaps give an unending supply of energy to an electronic device has fascinated numerous specialists and has brought a rising amount of researchers regarding energy harvesting. Energy harvesting works on the simple principle of deriving the energy from an external source and stored it for small and wireless autonomous devices. Due to the accessibility, abundant and consistent gravity all over the earth, it is feasible to generate electricity using the gravitational pull. This paper presents the working principle and elaborates performance evaluation of the system in different operation conditions. When weight falls from a height, it acquires potential energy, which is then converted into rotational motion with the help of a pulley. The pulley rotates the complex gear system coupled with the generator. However, the amount of energy generated by the proposed design is nominal but far more enough to operate many electronic devices in remote areas. Generation through gravitational pull demonstrates the system's reliability and cost-effectiveness, that can be used in the remote areas and enable the locals to create their own islanded power systems. The effect of changing weight and height is also presented and the system operation is verified from different experimental support.

Keywords: Gravity, Energy Harvesting, Renewable Energy, Gears, Weight, Electrification

Introduction

Ever since the concept of gravity is revealed to mankind, they utilized it to the best of their knowledge to harvest different forms of energy. Up till now, the gravitational energy has played a vital role in harvesting Hydal, Tidal, and Wind energies. But due to the fact, energy resources are progressively decreasing at a high degree. Within a few decades, the energy resources will vanish and hence there will be a lack of resources to generate power. So, there is a pressing need to develop different methodologies that can fulfill our requirement of using gravitational energy without the limitation of resources.

Gravity is the everlasting force known to be the vital force for the existence of the universe. This force is best described by Newton's law of gravity, which states that the force of attraction is directly proportional to the product of their masses and inversely proportional to the square of the distance between them (Williams, 2016). Moreover, Einstein apprehended this force as the cause of deformity in space-time fabric (Williams, 2016).

Although, this force is considered as the weakest of the four fundamental forces, yet it extends in the universe is infinite owing to the inverse relation to the distance parameter. On the macroscopic level, this force is responsible for the formation of the shape, the trajectory of the astronomical bodies, and governs the astronomical behavior. While on a microscopic level, it is responsible for the imparting weight to every matter that exists on earth (Shelar et al., 2017). This property of the gravity is broadly used in the configuration of generating power. So, with proper mechanism, it can be utilized to generate power regardless of place and time. Such a method will make it more convenient to generate power without any operational cost, sophisticated labor, and requires no definite terrain to install such a system. The major

advantage of generating power through gravity is that it causes no harm to nature and neither contributes to the greenhouse gas emissions unlike other conventional power plants like coal, diesel, etc. (Hardisty, Clark, & Hynes, 2012). Hence, this paper proposes a novel energy harvesting system design and method to generate power through gravitational force. And this novel design can be best utilized in rural and remote areas, where access to electricity is negligible or partial.

The proposed model is designed on a principle that allows the weight to fall gradually, to achieve maximum possible drop time whilst providing enough rpm at the generator shaft to generate power.

Sir Isaac Newton discovered Gravity for the first time about 400 years ago. After that, some scientists managed to produce such devices that delivered promising results as in reference (When gravity equals light, 2020). Two engineers from England Jim Reeves and Martin Riddiford designed a device called "Gravity Light", which uses 10-12 kilograms of weight to harvest 0.075 Watt of energy with total drop time of 20 minutes. Chun-Chao Wang and Yuh-Suiang Wang (2020) also presented a few concepts regarding the generation of power through gravity that mainly focused on the continuity and the stability of the power generated. In his concept, the gravitational potential energy is converted into kinetic energy, which is further being transformed into electrical energy. Russian Inventor, Mikhail Dmitriev used a wheel named "Gravity Wheel", where the masses are arranged on the outer edge of the wheel through a lever (PesWiki, 2020). Mass on the upper end of the wheel is deflected by the second small motor in such a way that the direction of force is acting outward, which pushes the wheel to move in a circular motion and hence, the power is generated by the generator coupled with the axis of the wheel. Moreover, Wagh (2018) presented a design that works on simple principle i.e. when one object is placed on a higher level (high potential energy level) and due to the gravitational pull, it is attracted towards the lower level (low potential energy level) and thus creating kinetic energy, this kinetic energy can be utilized in a precise manner to transform it into electrical energy, the fundamental concept utilized, is ‘perpetual motion’ that channelize the motion without the external source of energy and thus attaining a ‘perpetual motion’ using gravitational energy.

Computer Simulation

Autodesk Inventor is used to designing and simulating the proposed system device. Autodesk inventor allows creating mechanical designs with real-time simulation with the incorporation of all the environmental constraints. It converts all the computer-aided design (CAD) designs to 3D simulated designs and generating a simulated illustration of the final product, enabling the inventor and the researcher to validate the final product by its procedure, fitting, and the function of the product before going into the manufacturing phase.

The gear train system is designed and meshed together to simulate the torque and revolutions experienced at the generator. The Autodesk validated the gearing system design and its working by confirming various design parameters for the robustness and reliability of the gears (Figure 1).

For the final design, *E-Machine* software aided in the incorporation of the final arrangement of gears and generators. E-Machine is a 3D design software that is utilized by the researchers to create different 3D models and to authenticate their designs.

Experimental Setup

System Components

The gear train system is used as the major architecture of the proposed setup. A gear is a rotational motion transmitter, meshed-up with other gears using the teeth-cut on the surface. Stepper motor, as the name indicates, is a type of brushless DC electric motor used to rotate in

steps. In the novel proposed model, it is operated as a generator (rated 200RPM at 12V and 1.5A), delivering full sinusoidal current. A strong cotton string is used to tie the weight with the pulley and two panels of 18 LEDs, used as the load.

(a) **(b)**

Figure 1. (a) The side and (b) top view of the gear system developed in Autodesk Inventor software

Working Principle

When weight is subjected to fall from a height of high energy potential, converts the possessed energy into rotational motion of the pulley, resulting in the rotation of the gear system, coupled with the generator (stepper motor).

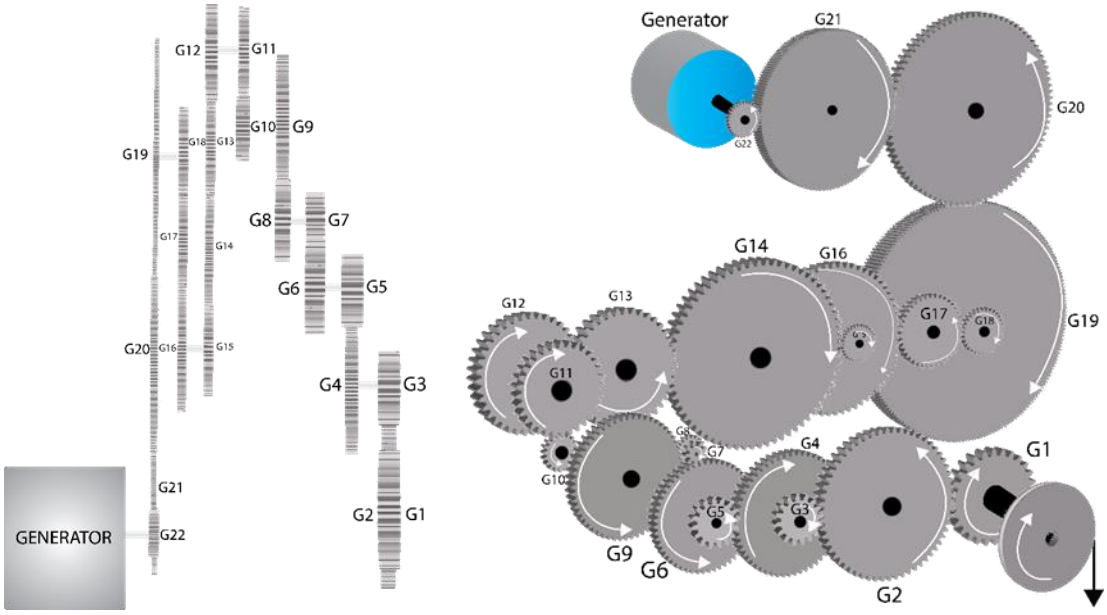


Figure 2. The schematic design of the complex gearing system

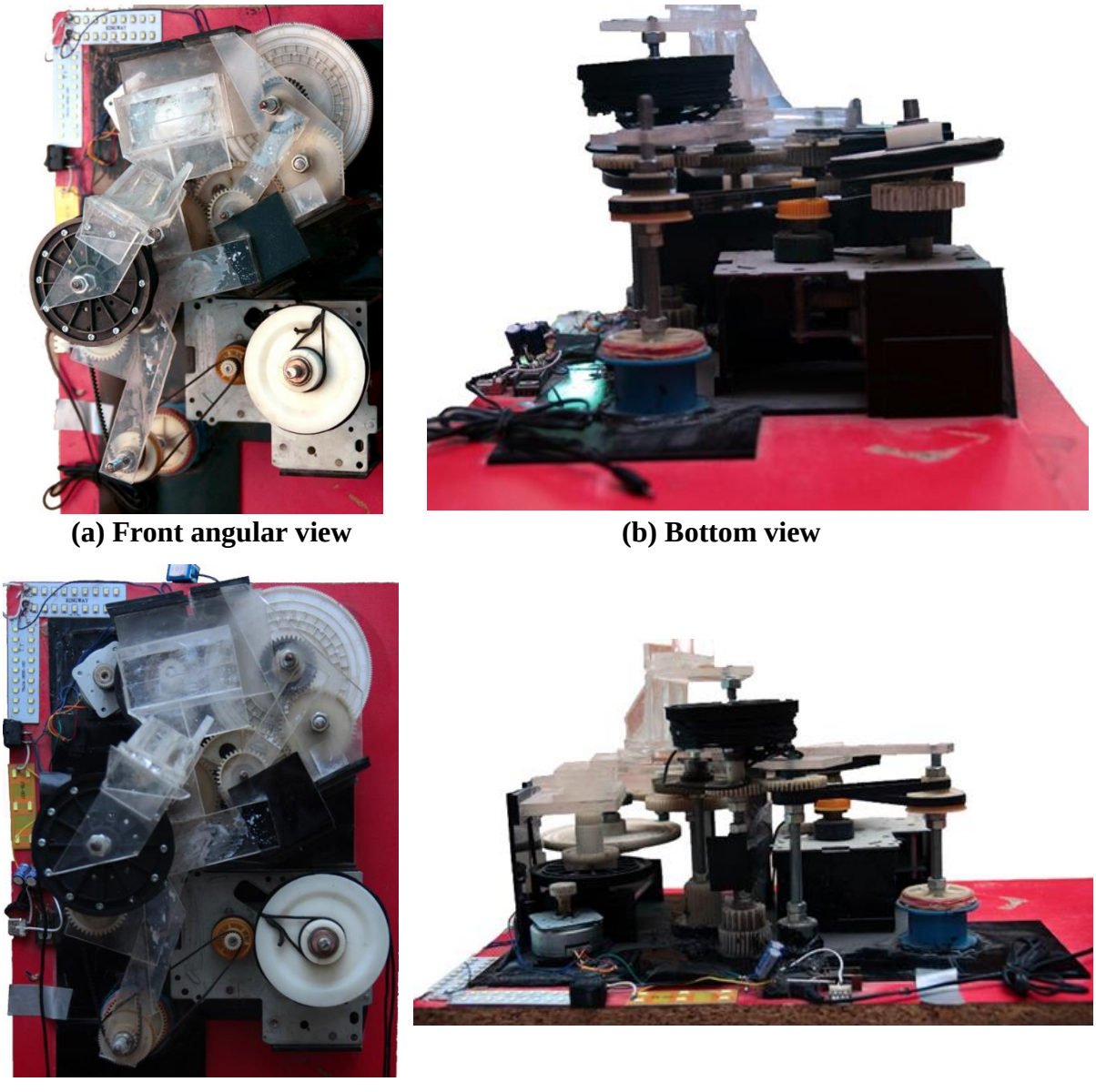
Construction

The design consists of weight, belt, pulley, gears, and generator. The arrangement of the pulley is such that it is coupled with weight "w", falling from a height 'h' under the force of gravity through the belt. The subjected fall of weight drives the pulley, which transfers the rotational motion to the gearbox that increases the rotational speed at the shaft. The output

(high-speed) shaft is connected to a generator that converts the rotational movement into electricity.

The gear system includes spur gears and helical gears, comprising different numbers of teeth, coupled with each other. The first gear consisting of 28 teeth, which is on the same shaft as a pulley, meshed with another gear containing 60 teeth as tabulated in Table 1. This arrangement results in an increase of the torque applied by the tangential force of the falling weight so as to increase the drop time.

The weight is hanged using cotton string, which is tied around the pulley. The pulley is then assembled with a complex gear train system, which is used to increase the revolutions at the generator end. The side and home view of the simulation is illustrated in Figure 1 and Figure 2.



(a) Front angular view **(b) Bottom view**

(c) Front view **(d) Left view**

Figure 3. Pictorial view of the novel power harvesting model

Table 1 demonstrates the diameter, coupling and, type of gears used in the design.

Assuming for the sake of simplicity, if 1RPM is generated on G1 with teeth 28 and mashed with G2 with 60 teeth, the revolution at G2 can be derived as:

Table 1. RPM calculation

G1	G2
28TEETH	60 TEETH
1 RPM	?

Then 28/60 = 0.46667 and

G2 = 1 * 0.46667= 0.46667 RPM

So, proceeding the same formula or procedure for the mashed gears, we can derive, the generated RPM is 55 on the generator shaft.

Electric Circuit

The Circuit consists of a full-wave bridge rectifier, 5 volts Voltage regulator lm7805, and Capacitors. The AC voltage from the generator is rectified using the full-wave bridge rectifier which is connected with a voltage regulator. The capacitors are connected to the voltage regulator to reduce voltage transients, hence, the regulated power is delivered to the load.

Results

All the experiments were performed in normal conditions with no special equipment used. Stepper Motor is used as a generator that produces pure Sinusoidal AC Current. The Output is provided to two different loads i.e. AC and DC. For DC load the output is rectified using Rectifier Bridge which is then connected with the load through a voltage regulator. The load used is a panel of light-emitting diodes connected in parallel. In the first reading, the total weight on the pulley was 3.295 Kg, dropped from a height of 6 inches. The total drop time measured was 1 minute and 10 seconds connected to the AC load. The same reading was taken with increased weight (3.705Kg) and the drop time decreased to 46 seconds. It has been observed, by increasing the weight, output voltage and current increased significantly.

The third and fourth analysis was performed with the same height and weights but the output was provided to the DC Load. The drop time was decreased to 57 seconds and 36 seconds respectively due to the usage of the small load as compared to the AC. The last two analyses were achieved with the total load connected to the same two weights and the drop time was measured as 1 minute 4 seconds and 46 seconds respectively. The total load increased the voltage, current, and drop time hence proving that the total generation depends on two parameters i.e. weight and the load, hence, the power generation is directly proportional to weight and load. However, time is inversely proportional to the weight and directly proportional to the load connected.

$$P \propto W, \quad P \propto L$$
$$T \propto L, \quad T \propto 1/W$$

Whereas, P represents the power generated, W as the weights attached to the pully, and the load as L.

Discussion

Since gravity is not intermittent as the solar and wind renewable energy resources. The un-reliable and changing nature of solar and wind energy resources makes it vulnerable and the high cost is also a major factor that restricts the authorities for its deployment in the remote and rough terrains. Along with that, to reduce and fill the gap due to the intermittencies, the Electrical Energy Storage (EES) units are mandatory with solar and wind power plants to make the sure the continuous supply of energy, hence adding the additional cost to the system.

Table 2. Diameter, coupling and type of the gears used in the design

G. No	T	Diameter (inch)	Shaft	Coupling		Type
				G	Ratio	
G.1	28	1.5	P	2	0.466:1	Helical
G.2	60	3.5	New	3	1:3.75	Helical
G 3	16	1	New	4	1:1	Helical
G 4	56	5	G 3	5	1:3.5	Helical
G 5	16	1	New	6	1:1	Helical
G 6	24	2	G 5	7	1:2.66	Helical
G 7	9	1	New	8	1:1	Helical
G 8	20	1	G 7	9	1:0.34	Spur
G 9	58	3.5	New	10	1:1	Spur
G 10	20	1.8	G 9	11	1:0.625	Spur
G 11	32	2	New	12	1:1	Spur
G 12	40	4	G 11	13	1:0.95	Spur
G 13	42	4	New	14	1:0.6	Spur
G 14	68	6	New	15	1:2	Spur
G 15	34	3	New	16	1:1	Spur
G 16	64	7	G 15	17	1:1.3	Spur
G 17	48	5	New	18	1:1.4	Spur
G 18	34	3	New	19	1:1	Spur
G 19	232	12	G 18	20	1:1	Spur
G 20	90	3	New	21	1:0.5	Spur
G 21	180	6	New	22	1:5.2	Spur
G 22	34	1.5	New	-	-	Spur
G: Gear; P: Pulley; T: Teeth.						

Since, the energy harvesting through gravity is a feasible, low cost, and a reliable source of energy. Such a system can be implemented in harsh terrains and remote areas due to the portable structure. In this design, we have achieved our desire result i.e. how to tackle the weight to increase its drop time and generating electrical power as an output. Nominal power is generated with different loads as tabulated in Table 3. The complexity of the mechanism is simulated in 2 different software to validate the performance of the design, especially the complicated gearing system.

The advantage of such an arrangement not only has the benefit such as: requires no operational cost, fuel cost, etc. but only needs the initial capital cost for the manufacturing purposes. Moreover, power harvesting through such a mechanism would enable us to overcome the chronic problem of global warming due to its environment-friendly nature. This setup can be easily incorporated in off-grid premises especially in rural areas and remote terrains, which is far-flung from grid station and with no electric utility infrastructure. The power generated from the designed model can be utilized for low wattage electronic devices like cell phones, radio, and other charging equipment.

Table 3. Experimental results

S No	Weight (kg)	Time	Load	Power (W)	V	I (mA)
1	3.295	1:10 sec	AC	0.016	2.16	7.5
2	3.705	46s	AC	0.085	3.027	28.2
3	3.295	57s	DC	0.0101	2.6	3.9
4	3.705	36s	DC	0.0427	2.7	15.84

5	3.295	1:04s	Total	0.0953	5.5	20.65
6	3.705	46s	Total	0.154	6.676	37.01

In the future, the systems can be redesign or altered for high energy production and high weight fall durations. The portability of the design can be reformed in a smarter casing for the protection of the complex gearing system. The device is currently working on low efficiency due to the internal friction and the external surrounding forces. The design can be made more efficient if it is subjected to work in an isolated environment as Flywheel.

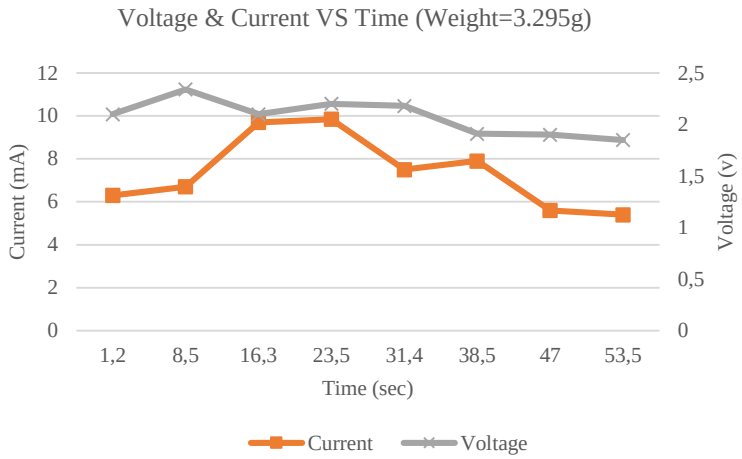


Figure 4. Voltage and current analysis at 3.295kg

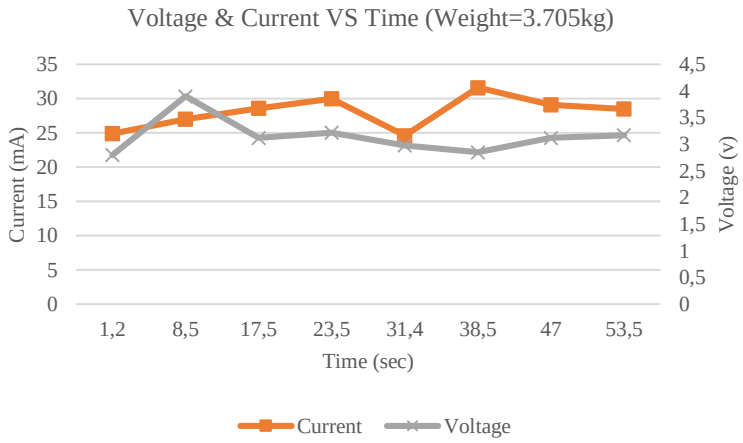


Figure 5. Voltage and current analysis at 3.705kg

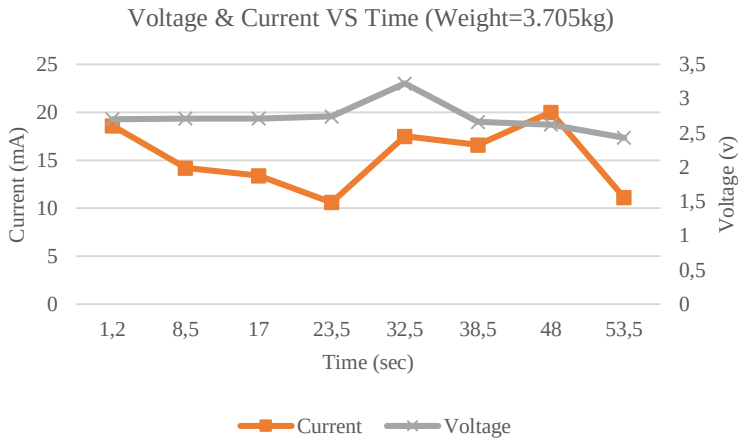


Figure 6. Voltage and current analysis at 3.705kg

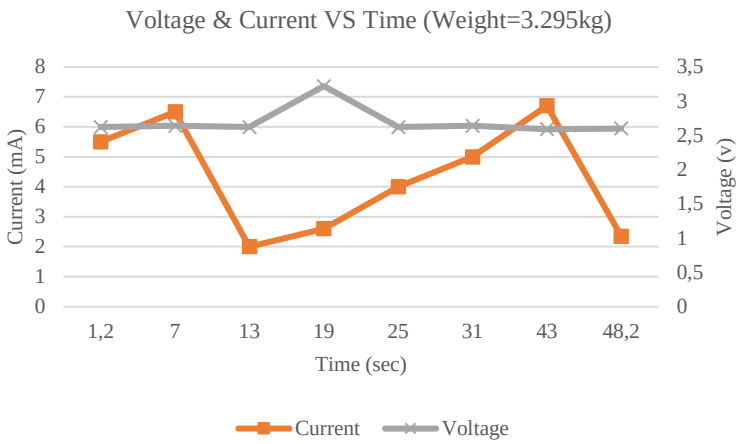


Figure 7. Voltage and current analysis at 3.705kg

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