Design and Development of Gravity Lamp

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Abstract- *The depletion of conventional energy resources and the growing concern of the greenhouse effect due to its exploited utilization are forcing engineers and scientists to harness electricity from non-conventional sources of energy. Gravity being abundant and constant all the time with same intensity can be harnessed to generate electricity by using gravity potential energy stored in a mass raised to height above the Earth's surface. With the help of this potential energy stored in a falling mass electrical energy is generated which is supplied to a dynamo used to power LED bulbs. In order to achieve this a mount was designed which carries a bicycle wheel at one end and a pulley at the other end and the drive is transmitted through a V-belt. The pulley further drives a dynamo whose leads are connected to a breadboard having an LED light connected to it. This setup gives enough energy to illuminate a room. The project will help in obtaining electricity with minimum manual labor and can be used in remote places or in rural locations where means for providing electric energy is cumbersome and infeasible.*

Introduction

Approximately 1/3 of the World's population is off-grid (having no access to mains power). This situation is not set to change in the near future, according to the World Bank and the World Health Organisation, and is identified as a major obstacle to the proliferation of education, and recognised as a limiting factor for growth in developing economies. The vast proportion of existing solutions for heat and light in remote, off-grid, areas rely on bio-mass (carbon-based fuel sources). Concerns over ecological impact aside, a reliance on burning biomass for lighting (specifically oil) is expensive, keeping millions in fuel poverty, is unhealthy (producing toxic fumes and poor quality light) and dangerous (fire). Initial Brief for 'Carbon-Free Kerosene Lamp' that led directly on to 'Gravity Light': The charity SolarAid identified kerosene (known in the UK as paraffin) as the predominant, bio-mass fuel source burned for lighting across developing African nations. They also identified some obstacles to the adoption of alternatives to kerosene that seemed to exist. Consequently, they formulated a brief for us to design a non-kerosene powered product that they felt would be more readily adopted by end users in these markets. This project was started in mid-2008. They had observed that many individuals own traditional kerosene lamps and have usage patterns that are highly adapted to these devices, such as night fishermen who hang the robust, tin (and fragile glass) products on the end of long poles, erected at the prow of fishing boats. Solar-aid felt that if these kerosene lamp bodies could be adapted to run off a non-biomass power source, while maintaining familiar product semantics, consumer acceptance would be more widely, and quickly, achieved. Lastly, they felt that an additional benefit to the adaptation of existing kerosene lamps would be access to funding mechanisms within the carbon credits scheme for which they could qualify, where they hoped to trade carbon credits through demonstrating quantities of converted lamps that no-longer relied on carbon-based fuel sources.

Literature Review

Problem Definition

To design and manufacture a portable, eco-friendly power generation device/setup/machine for converting gravitational potential energy into electrical energy which can be used for applications like lighting, run motors, charge batteries and other electrical/electronic appliances. The purpose of this device/setup/machine is to provide power source to cater electricity requirement.

Objectives

1) To find an eco-friendly solution for domestic & street light electrification applications using stored muscular energy in the gravitational potential energy.

2) Prolong the usage of stored muscular energy.

3) Generating significant amount of power for domestic application.

4) Practically tested results and mathematically evaluated results are to be compared & if necessary, the required modifications need to be incorporated.

5) Making a working prototype of the concept of electricity generation using gravitational potential energy.

Concept Generation, Selection and Validation

Concept for Mechanism of Gravity Light

A suitable mechanism for the working of the gravity light was to be selected. After considering a number of designs and discarding a few we came up with three major design concepts which can be used for generating electricity. Following are the concepts: -

Spring Actuated Gravity Lamp

The weight is attached to a rope which is wound over a pulley whose center consists of a spring which is normally unwound. The spring is fitted onto a shaft through a slot in the shaft and is wound over the shaft. The winding of the spring causes the spring to compress under tension and rotate the shaft along with the winding action. This rotates the pulley and the weight ascends. After a certain height an initial tension is given to the spring and the spring starts unwinding slowly at a constant rate depending on the weight attached to the rope end. The force of the unwinding force rotates the shaft and helps control the descent rate of the weight. This shaft would be further connected to a dynamo shaft which will provide us with the required electricity.

Counter Weight Type Gravity Lamp

This employs the use of counter weight principle for lowering the weight and in turn maintains a control on the descent rate of the falling weight. If the weight to be lifted is 'x' then the counterweight that must be added so that the weight just stars to descend is 'x+0.9'. The weight will be attached to the rope of a pulley and this pulley will be mounted over a shaft which will be connected to the dynamo shaft producing electricity.

Bicycle Wheel Type Gravity Light

This concept is the most practical one out of the three and it involves a rim of a bicycle wheel from which a shaft protrudes supported by bearings and has a sprocket onto which a chain of required pitch and length is mounted. The weight is mounted on one side of the chain and this is suspended over the sprocket and lifted by mechanical means to a certain height. The sprocket is given an initial torque and due to the self-weight and gravity the weight falls down at a controlled decent rate.

Concept Selection

After a close deliberation of all the concepts generated we made a matrix to determine the concept to be used for the working of the gravity light. This matrix consists of the attributes the product is supposed to have and is compared for all the three concepts generated. Each of these attributes are graded according to the data from the market survey and their importance in the product design. Accordingly, the concepts were marked out a maximum score of ten and the grade of the attribute was multiplied to get the sore of the concept for one particular attribute. The total score was calculated and marks were given out of the total overall score of the attributes and the marks obtained by the concept. In the following table there are eleven attributes and three concepts to be verified. The concepts were graded on a total score of 1100. Some of the attributes were judged using expert personal judgment and the marks for the concept were given accordingly.

After careful study of each concept and computing their score on the attribute matrix it was found that the Counter Weight Mechanism and the Bicycle Wheel Mechanism had the highest score and can be combined to make an effective model of the gravity light mechanism. Hence the spring mechanism was discarded and the design parameters for both these mechanisms were decided upon completion of selection of concept.

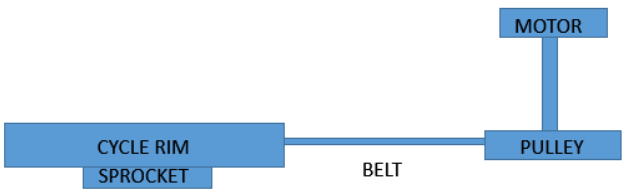
Design and Manufacturing

The approach for designing the mount, mechanism for suspending the weight and was kept as simple as possible.

List of Components

Components	Specifications
Chain & Sprocket	Z=18, PCD=8 cm, c=25.12cm , p=2.5cm , L=500 cm
Bicycle rim	D=56.65cm
Triangular frame of chassis	B=45cm, H =44cm, slant height =48cm
Angle plates	L=10.5cm, t=0.4cm, no.of angle plates=3
V-belt	A-type L=73cm
Pulley	Bore =1.5cm, d=8cm
Shaft	d=1.5cm, l=11.5cm, drill=6mm, step=8mm, drill tap=3mm
Motor	12V, 7 RPM DC motor
Base plate	(61X23X0.5) cm, holes of diameter 1cm, N=4
Support strip for pulley	(15X6X0.4) cm, drilled hole of 1cm diameter

CALCULATIONS:



Schematic Figure for Torque Calculation

Reduction ratio =R=56.65/8 = 7.08

R=1:7

For 10 RPM at the motor shaft, it took 1.5 RPM on the input shaft.

RPM of rim = Rpm of sprocket

0.25*1.5 = 0.375 meters.

For 1.5 RPM of sprocket i.e. for every minute the weight descends down by 0.375 meters.

Therefore, for 15 minutes:

15*0.375=5.6 meters height is required.

Torque calculations:

Torque at output shaft = 3.34 Nm

The above required torque is transmitted to output via belt driven pulley.

Reduction ratio : 1:7

Therefore,

Torque at output / Torque at input = RPM at input/ RPM at output

3.34/torque at input = 1/7

Torque at input shaft =3.34*7= 23.38 Nm.

Thus,

Torque at output shaft =3.34 Nm

Torque at input shaft =23.38 Nm

Torque at output shaft = 3.34 Nm

Torque = radius * force

3.34=0.04*force

Force=3.34/0.04=83.5N

Results and discussions

The following results have been obtained after performing the trials on the actual setup: -

Trial No.	Time of Descent(s)	Weight(kg)	Height(m)	Wattage(W)	Luminosity
Trial No.1	2.62	1.5	2.43	15	4 glows, good
Trial No. 2	2.43	1.5	2.43	6	Very Good
Trial No. 3	2.47	1.5	2.43	9	Good
Trial No. 4	1.41	2.5	2.43	12	OK
Trial No. 5	30	7	1.8	3	OK
Trial No. 6	100	40	1.8	6	Good
Trial no. 7	103	20	1	3	Good
Trial no. 8	102	26	1.6	3.5	Good

The weight required to drive the dynamo is heavier than expected.

For this a chain pulley block can be arranged to facilitate in lifting the weight.

Mechanical losses are significant due to pulley, chain - sprocket and bicycle wheel.

The illumination obtained from the setup is sufficient to brighten a small area but with reflectors, an entire room can be illuminated.

Conclusion

Target specifications of 8 ft, 30 sec and 15 W could not be met with this configuration.
We could generate 3.5 W with 4.45 min, 1.6 m height and 80 kgs of weight.
The amount of weight required to drive the machine is very large than what we expected.
The rate of descent can be controlled by electrical loading.
The machine can be build from easily available inexpensive materials
Weight, length of descent and time are critical trade-offs in the working of the machine.

References

1. "Gravity Light Description of the Concept and its Realization" archived at http://archive.aec.at/ last accessed on 15th May, 2016
2. Scientific Advisory Panel Briefing: Kerosene Lamps & SLCPS dated 12 November 2014 archived at http://www.ccacoalition.org last accessed on 24th April, 2016.
3. Lam NL et al, "Household light makes global heat: high black carbon emissions from kerosene wick lamps". Environ Science Technology 46(24):13531-13538.
4. Environment Protection Agency 2012 archived at https://www3.epa.gov/climatechange/ghgemissions/sources.html and http://www.eia.gov/tools/faqs/faq.cfm?id=77&t=11 accessed on 19th May, 2016.
5. IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation prepared by O. Edenhofer et al Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1075 pp. (Chapter 9).
6. Union of Concerned Scientists archived at http://www.ucsusa.org/clean_energy/smart-energy-solutions/increase-renewables/clean-energy-green-jobs.html accessed on 19th May, 2016
7. Trieu Mai et al "Renewable Electricity Futures Report" Volume 1 Pg.10
8. Machol B et al, "Economic Value of U.S. Fossil Fuel Electricity Health Impacts."
9. http://www.fastcoexist.com/3050137/hows-that-working-out-for-you/this-ingenious-20-lamp-gets-all-its-energy-from-gravity accessed on 19th May, 2016.