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Eco-Peddler Bicycle Power Generation and Feasibility Analysis

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ABSTRACT

In our present life we are facing an avoidable frequent power cuts for about 2-3 hours a day on an average which is hardly been controlled by wealthiest using other expensive power generation source like Diesel Generators, Solar Cells etc. but for middle class or below average people it is quite unaffordable. To overcome this problem in this project bicycle pedalling concept is employed which is beneficiary in two way It will help in electricity generation whenever needed or can be stored in battery power pack. It will also help people in maintaining the fitness of the body. Human power credit is more because of health benefit as a source of energy. More effective use of human power could be achieved through properly designed mechanisms. The main objective of this paper is to convert the rotational energy of rare wheel of the bicycle into electrical energy so that we can recharge the battery and the feasibility is analyses.

Keywords: *Bicycle; Battery; Energy generation; Scavenged energy; Energy conservation.*

1.0 Introduction

India stands second in population in the world. With the increasing population the needs for power are also increasing, in such cases demand of electricity is very high. Non–commercial fuels constitute around 74% of energy requirements in India. Around 97% of the Indian villages are electrified, but many of the remote villages are still without electricity. The idea of human powered generation has been implemented in many different situations. Some examples include hand-crank radios, shaking flashlights, and receiving power from gym equipment. The use of exercise equipment for a clean source of energy would turn out to be an even more fun experience for participants; it would provide them a means to exercise while indirectly generating power. To meet the energy requirement concept of Pedal Operated Power Generator is implemented in this project which utilizes human energy to produce electricity quickly and efficiently. The goal is to convert the human power into some useful energy and use it whenever required which may gone in waste maintaining fitness. Using human powered generation gives a power source that is independent of PowerGrid that generates power using natural sources. It can be operated if there is no sun for solar generation, no wind for wind generation, and no water for hydro generation. The power generated from pedal is perfect for remote areas, hilly regions, strategic location, Islands etc., were electricity generation very less or nil. In these situations, a small portable power generating unit would be of great help to provide power supply to charge battery-operated gadgets like mobile phones, lamps, radio, communication devices, etc.

It is important to visualize new ways to bring power to the people as population continues to grow and power shortages continue to occur. This design relates to very compact and easily portable power-generating unit, which besides being used as a power generator can also be used as cycle exerciser. It serves dual purpose of power generation and helping the person to maintain physical fitness through exercise of muscles of legs. It can be pedaller cranked by hand/foot to charge 12-volt batteries and run small appliances.

2.0 Objective

In order to meet our objectives, we developed a series of tasks to complete associated with each objective which are as follows:

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2.1 Primary objectives

Objective 1 Low Electricity Production Cost:

- The primary object of this project is to generate electricity without any additional operating cost.
- Electricity generated can be easily affordable in rural areas where there is no electricity or if available is an extra burden on monthly expenditure.

Objective 2 Power Independency and Fitness:

- Through this project we want to make understand that we no longer need to be dependent on anyone or anything for electricity.
- Everyone is capable of generating power for their use irrespective of the area they are living.
- To utilize the energy in more beneficial way which would go in waste during exercise for maintaining fitness of body.

2.2 Secondary objectives

2.2.1 Objective 1 designing

- Design basic assembly of the parts in CAD.
- Analyse the design and its efficiency against the stress generated.
- Design a circuit to protect the batteries during charging and discharging.

2.2.2 Objective 2 research

- Research batteries and choose the best type for storing the electricity.
- Design a circuit to protect the batteries during charging and discharging.
- Model a concept battery pack.

2.2.3 Objective 3 charging system

- Research compact mechanical and solar power generating systems.
- Use CAD to model mechanical bicycle generator options.
- Propose and evaluate multiple system designs.
- Determine which bicycle generator option is best by evaluating the advantages and disadvantages of multiple generator designs.

2.2.4 Objective 4 output power module

- Conduct a survey to determine necessary Appliance's preferences.
- Select the appliances that will meet user preferences as well as meet the technical demands of the system.

2.2.5 Objective 5 testing

- Test the entire system as it would be used by riding a bicycle with the mechanical generator for an hour & determine how much the battery pack is charged.
- Discuss the results of testing the entire system and determine the feasibility of manufacturing.

3.0 Literature Survey

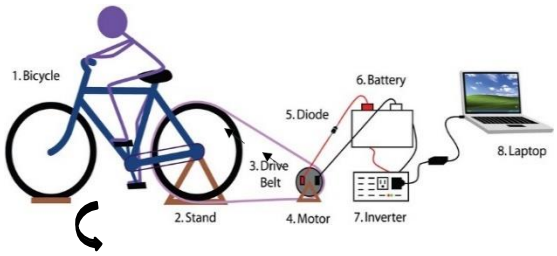
Throughout human history, energy has generally been applied through the use of the arms, hands, and back. With minor exceptions, it was only with the invention of the sliding-seat rowing shell, and particularly of the bicycle, that legs also began to be considered as a "normal" means of developing power from human muscles (Wilson, 1986). Over the centuries, the treadle has been the most common method of using the legs to produce power. Treadles are still common in the low-power range, especially for sewing machines. Historically, two treadles were used for some tasks, but even then, the maximum output would have been quite small, perhaps only 0-15 percent Innovative Systems Design and Engineering of what an individual using pedal operated cranks can produce under optimum conditions. However, the combination of pedals and cranks, which today seems an obvious way to produce power, was not used for that purpose until quite recently. It was almost 50 years after Karl von Krais invented the steerable foot-propelled bicycle in 1817 that Pierre Michaud added pedals and cranks, and started the enormous wave of enthusiasm for bicycling that has lasted to the present. Ever since the arrival of fossil fuels and electricity, human powered tools and machines have been viewed as an obsolete technology. This makes it easy to forget that there has been a great deal of progress in their design, largely improving their productivity. The most efficient mechanism to harvest human energy appeared in the late 19th century pedaling. Stationary pedal powered machines went through a boom in the turn of the 20th century, but the arrival of cheap electricity and fossil fuel abruptly stopped all further development (Kris, 2011). Otto Von Guericke is credited with building the first electrical machine in 1660. This form of electricity precedes electromagnetic energy which dominates today. The landscape for today's electricity usage practices bloomed from 1831 to

1846 with theoretical and experimental work from Faraday, Weber and Gauss in the relationship of current, magnetic fields and force. These theories enabled the design modern motors and generators. From 1880 to 1900, there was a period of rapid development in electrical machines. Thus, this section reviews the works that has been done on human power generation.

4.0 Basic Configurations of Bicycle Generator

The basic configuration of a bicycle generator consists of rider input where rider releases energy through pedals. This input energy from rider is further transferred through Chain & Sprocket gear Mechanism to the rear wheel of the bicycle. The rear wheel is connected to the pinion of the Alternator which converts the rotational energy of the wheel into Electric energy through belt & pulley mechanism. Once the alternator meets sufficient speed, it starts generating electricity. This generated electricity is then stored in battery which can be utilised by using invertor in case of AC appliances or directly for DC appliances as shown in Figure 1.

Figure 1: Bicycle Generator- Energy Generation and Distribution and Parts



5.0 Advantages & Disadvantages

5.1 Advantages

- Portable: It is a portable device which is easily detachable and can be transported to any remote area.
- No operating cost: It depends only on mechanical work from humans so it is free of any operating cost.
- Economical: It is free source of electricity, though it requires some mechanical work which can be done in any leisure time so it is economical.
- Health improving: Cycling makes one to be fit and healthy.
- Eco-friendly- It doesn't emit any kind of harmful substances in the environment so we can say it is eco-friendly.
- Robust and simple circuit: This circuit requires only five components which are small in size and robust. This makes it simple in design.
- Very low maintenance: No need of maintenance as devices are very cheap.
- Better performance on Li-ion battery: In our research we found that Li-ion batteries are quite efficient in charging and discharging when compared to Lead-acid battery.

5.2 Disadvantages

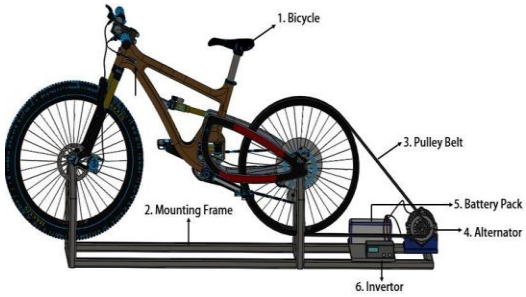
- Energy losses: Some amount of energy is lost in the form of friction between rear wheel and the motor pulley during pedalling and in form of heat in the motor.
- High speed: This system needs little high speed in order to generate electricity.
- Dependency on Rider: The energy output is dependent on the rider as long as he peddles.
- Initial Cost: The initial cost of the system will be bit much as in this system is using Li-ion batteries which are costlier.

6.0 Construction

The entire design of bicycle power generation and its feasibility includes; Bicycle, Alternator, Pulley Belt, Battery, Invertor and Frame for mounting. The back wheel of the bicycle coupled with the generator through belt. The belt is placed over the rim of the wheel and the pulley of the generator which is connected to the battery. An inverter board is connected in series which gives the provision for output load. The two terminals from the generator are connected with battery. The battery is used to store the electricity, as the current produced in the D.C form it can be directly stored in the battery. The invertor converts Direct Current to A.C current. Finally, the inverter board is connected with the power terminal for power supply. CAD diagram of the experimental setup is shown in the figure 2.

Figure 2 a: Eco-Pedaller (Isometric View)

Figure 2 b: Eco-Pedaller and its Parts



7.0 Major Components Its Speification

7.1 Bicycle

A bicycle is a human-powered, pedal-drive mechanism which converts human energy into rotational mechanical energy. A sprocket or sprocket-wheel is a profiled wheel with teeth, cogs, or even sprockets that mesh with a chain, that helps in rotating the rear wheel of the cycle.

Specification: In this project we are using a normal sports bicycle which is having a rear wheel of diameter 640mm and width 60mm.

7.2 Alternator

An alternator is device which is used to convert the rotational mechanical energy into electrical energy, which is shown in the fig. 1.4.

Specifications: Power- 40 W, Voltage – 12-13.5 V, Current - 90A, Brand Bosch.

7.3 Battery Pack

The alternator is connected with the Li-ion battery and the inverter board.

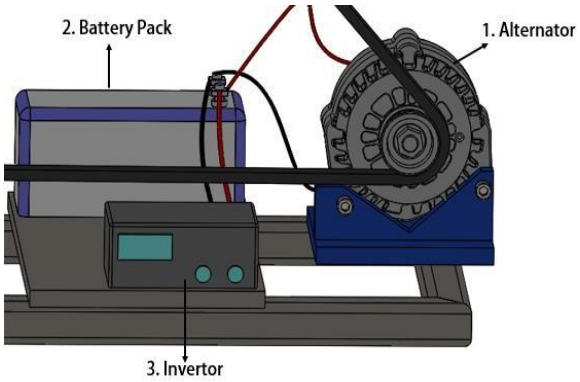
Specifications: Voltage - 12.0 V, Nominal capacity 50000 mA, 240 W/hr., Maximum discharging current - 130 A.

7.4 Invertor

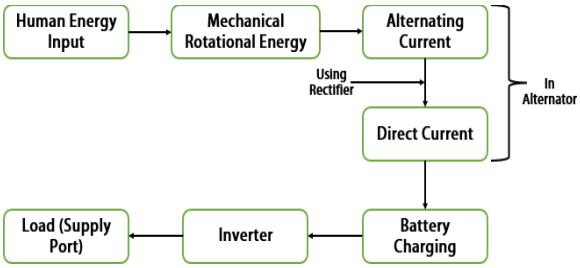
Next step is to convert from 12 vdc to 230 v ac for this there is a need to design an inverter which best suits this model which is shown in figure 3. Based on requirement inverter rating is selected, the proposed system uses 50-watt inverter which inverts from 12v dc to 230 v.

Specifications: Voltage – 220-230V, Power – 50W, Frequency – 50Hz, Type - A.C.

Fig 3: Power Unit of the System



8.0 Block Diagram

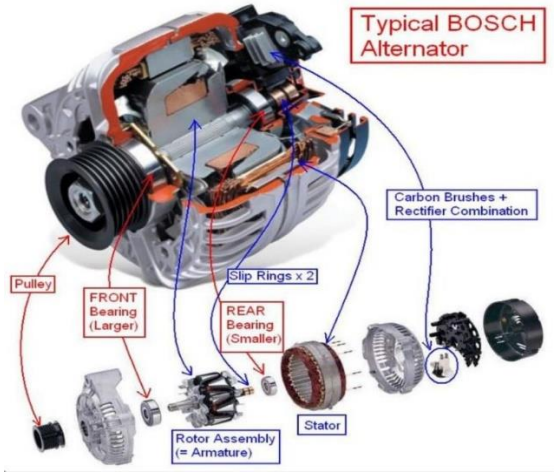


9.0 Working Principle

Principle of Alternator: An electrical generator is a device that converts mechanical energy to electrical energy, generally using electromagnetic induction. The source of mechanical energy may be a reciprocating or turbine steam engine, or any other source of mechanical energy. The alternator generates alternating current electricity and that is why it is called an Alternator. So, to get Direct Current an alternator uses a rectifier to convert Alternating Current to Direct Current. An Alternator uses electromagnetic principles to convert mechanical rotation into an alternating electric current. It consists of two main parts stators with star configuration which is connected to a rectifier and a

rotor which rotate within the stator. The energy conversion in generator is based on the principle of the production of dynamically induced emf. Whenever a conductor cuts magnetic flux, dynamically induced emf is produced in it according to Faraday's Laws of Electromagnetic induction. This emf causes a current to flow if the conductor circuit is closed. Hence, two basic essential parts of an electrical generator are (i) a magnetic field and (ii) a conductor or conductors which can so move as to cut the flux.

Figure 4: Car Alternator

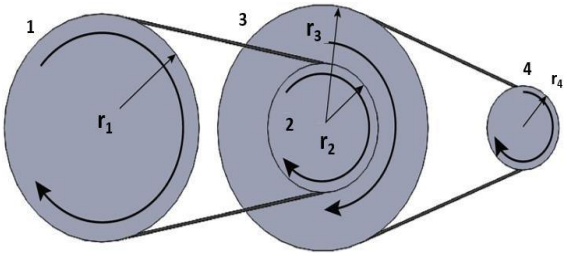


As per the design the bicycle generator constructed. In this manual load is applied on the bicycle pedal due to the manual force the largest sprocket starts to rotated. The largest sprocket is connected with the small sprocket in the back end by simplex chain. There by the small sprocket also starts to rotate. The small sprocket is placed in the center shaft of the rear wheel. So that the rotating motion of the center shaft transmitted to the back wheel there by the rear wheel also starts to rotate. The rear wheel is coupled with the alternator through flat belt. Now the motion is transmitted to the alternator that convert this mechanical motion into electrical energy. The current produced is in the form of D.C so it can be directly stored in the battery. The inverter board is used to convert the D.C current into A.C current and then it sent to the supply port.

10.0 Power Producton Calculation

The amount of power produced by the bicycle generator measured with the help of Ammeter and voltmeter. From the current and voltage, we can calculate the power. The amount of power by the bicycle generator in one hour is calculated in watt-hour is shown below

10.1 Mechanical input power



Single Belt Transmission- one driving and one driven pulley

For a system with two shafts and two pulleys- as indicated with pulley 1 and 2 in the figure above:

$d1n1=d2n2$ …(1)

where

d1 = driving pulley diameter (inch, mm)

n1 = revolutions of driving pulley (rpm-rounds per minute) d2= driven pulley diameter (inch, mm)

n2 = revolutions of driven pulley (rpm- rounds per minute) Equation (1) can be transformed to express the Revolution of Driven Pulley

$n2 = d1\ n1 / d2$ …(2)

Revolution of Driver Pulley

$n1 = d2\ n2 / d1$ …(3)

Diameter of Driven Pulley

$d2 = d1\ n1 / n2$ …(4)

Diameter of Driver Pulley

$d1 = d2\ n2 / n1$ …(5)

Multiple Belt Transmission Systems

For a system a with three shafts and four pulleys - as indicated in the figure above:

$n2 = n3$ …(6)

$n4 = n1\ (d1*d3) / (d2*d4)$ ….(7)

Here,

d1 = 160 mm

d2 = 60 mm

d3 = 640 mm

d4 = 50 mm

n4 = n1(160*640) / (60*50) 2500= n1(160*640) / (60*50)

As n2 = n3

n1 = (2500*50*60) / (160*640)

n1 =73.20 rpm

Speed required to the driver pulley is n1=73.20 rpm

Force input = mass*9.8 = 70 N

Torque on pedal = f *d = (mg)*0.17 m = 70 * 0.17 m = 11.9 Nm
Power = T*ωm = 11.96* (73.2* 2π/60) = 91.25 joule/s or Watt.

The amount of power by the bicycle generator by one person in one hour is 91.25 Watts-hr. So, for a family of 5-6 members the power produced by them cycles in hour 456 Watts-hr as shown in the table 1.

Table 1: Power Produced by Bicycle Generator

Bicycle Usage	Time (hrs)	Power Generated (Watt)
1	1	91.25
5	1	456

10.2 Charging time of battery

Charging current capacity is purely dependent on the battery capacity. Charging time of battery = battery Ah/Charging current
T=Ah/A Where,
T= charging time Ah= battery rating
A= charging amperage
As for the battery we are using 50 Ah batteries

First, we will calculate charging current for 50 Ah battery. As we know that charging current should be 10% of the Ah rating of battery
So, charging current for 50Ah battery
= 50*(10/100)
= 5 Amps

But due to losses, we can take 5 to 6 Amps for charging purpose. Suppose we took 6 Amp for charging purpose,

Then charging time for 50 Ah battery = 50/6
= 8.33 hrs.

But practically this is noted that 2-3% of losses (in case of battery charging) that can be neglected.

Therefore, a 50Ah battery would take 8 Hrs. for completely charging (with 6 A charging current) this was an ideal case

10.3 Discharging time of battery under load (for 1 bulb)

Discharging time of the battery is given by the following expression Td= Battery rating * Battery Volt / Applied load as for our battery rating is given as 50 Ah and the working voltage is 12 V and the applied load which is a LED bulb of rating 9 Watt
We have the following solution Td= (Battery Ah * 12 V) / 9 Watt
= (50 with 8% loss at maximum *12V) / 9
= (46 * 12) / 9
= 61.33 hrs.

For sure, the backup will last up to 61.33 hrs. Load= 9 W, Battery rating = 12V, 50 Ah.

Based on average backup of one bulb we can calculate the total backup for the appliance we are going to load on the battery. In this case we are using 3 bulbs, one table fan as shown in table 2.

Table 2: Power Consumption Rate of Home Appliances Based on Project Design

S. NO	Electrical component	Power Rating	Power Consumption (Watt-hr)	Battery Backup
1	LED Bulbs(3 Nos.)	9	27	8.5
2	Table Fan (1 Nos.)	35	35	

10.4 Converting power consumption rate into unit for 8 hours

As the appliances are running on power generated by Bicycle generated therefore that much electricity is saved from the incoming. So, we can calculate the savings on electricity bill by converting the energy into units as shown in table 3.

Table 3: Power Consumption Rate of Home Appliances Based on Project Design

S No.	Electrical Components	Power Consumption (Watt-hr)	Power Consumption in 8hrs	Power (Unit)
1	LED Bulbs (3 Nos.)	27	216	0.216
2	Table Fan (1 Nos.)	35	304	0.304

The table 3. Shows the power consumption rate in terms of Unit. Unit means the amount of power spend to operate the appliance in one hour measured inters of Kw. 1 unit is equal to 1000Watts or 1 KW.

10.5 Power consumption calculation in terms of rupees for 8 hours

S No.	Electrical Components	Power Consumption (Units)	Electricity Rate (Rupees/unit)	Amount (Rs.)
1	LED Bulbs (3 Nos.)	0.216	6.25	1.35
2	Table Fan (1 Nos.)	0.304		1.90

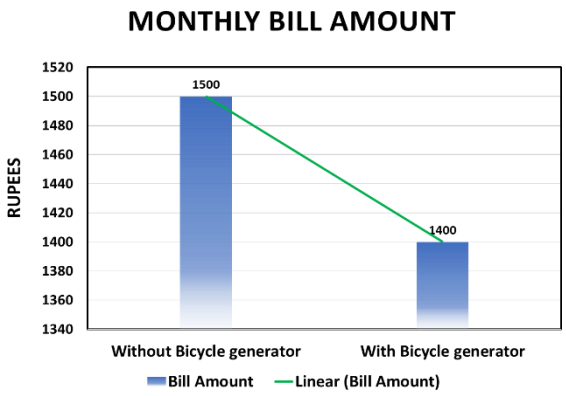
10.5 Expense calculation for one day

Amount based on project design = 1.35 + 1.90 = Rs. 3.25. The amount spent to operate 3 LED bulbs for 8 hour is Rs 1.35 and the amount spent to operate 1 table fan for 8 hour is Rs 1.9 the summation of all the amount gives the total amount spent to operate the appliance is Rs 3.25.

10.6 Expense calculation for one month

Amount based on project design = 3.25 X 30 = Rs.98-100. By multiplying the amount spent for one day with the total days of a month we get the amount spent for electricity for 1 month that is around Rs 100.

Figure 5: Monthly Bill Comparison with and without Bicycle Generator



The figure 5. shows the comparison between the Average monthly bill of with or without Bicycle Generator. The lower slanting line show the power-cost relationship representing the reduction in monthly bill. The graph shows the feasibility level of this project.

11.0 Conclusion

In conclusion, this project was designed to serve as a model/prototype to meet specific need in locality. At a time when energy crisis casting its shadow all over the world, one has to look into alternative renewable energy resources The device can also serve as an alternative power source in extreme case scenario even in urban centers. Since the device is manually operated, it can be used in areas where there is no power supply and would always be readily available. It is a useful machine where there is lack of power, also the cost is very low. Easy to maintain and make. Moreover, it is a good exercise of pedalling which makes us fit The device is environmentally friendly as it produces no waste in the process of its operation, and the device work with little or no noise. The system proved efficient since even with a minimum pedaling speed, the system produced enough voltage required to charge the battery in order for the system to be usable by almost anybody at any time.

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