Pedal Powered Electricity Generator

By

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Abstract

Pedal Powered Generators have been of interest at many places where no other alternative electricity generator has been viable. While using pedal power is not a new concept in itself, it has not been successfully used on a wider scale. There are a lot of schools in rural India, which are residential and are not grid connected. A pedal power generator with a lighting system was developed for such schools and tested. It provides 40 minutes of lighting for 10 minutes of pedaling. Currently about 10 such lighting systems are in use all over India and more are being shipped.

Introduction

India is the second most populous nation in the world. Like many other countries where agriculture is the main activity, biomass and other non-commercial fuels constitute around 40 percent of energy requirements in India. Around 85.49 percent of Indian villages are electrified.[1] Many will not be electrified for considerable time. Many schools in rural India are residential schools (including primary schools). Children and staff live within the school campus. Evening hours is the time when the students do homework and other reading activities. Most of the schools use kerosene lamps for lighting during evening hours. This is an inefficient way of lighting and does not provide enough light anyway. There are not many other ways of lighting left for these schools, as generators are too expensive and difficult to maintain. Most of the times fuel is too far away and difficult to carry over terrains, and often there are no roads to reach the schools. These schools typically need light for about four hours every evening and about one-two hours every mornings. The light needed is mainly for reading. These schools have between 40 to 100 children. They also have 3 or 4 staff families. Civil society organisations often work in areas that have no electricity. They hold meetings and programmes where electricity is needed for talks or for audio-visual equipment or for other miscellaneous purposes.

A totally different approach was taken to design the machine. The machine was designed and fabricated by the manufacturing facility itself and field testing was done by end users themselves and not by 'engineers' or 'scientists'. The Locally available parts were used to make the machine as far as possible and the product was continuously tested with the users directly

Why Pedal Power

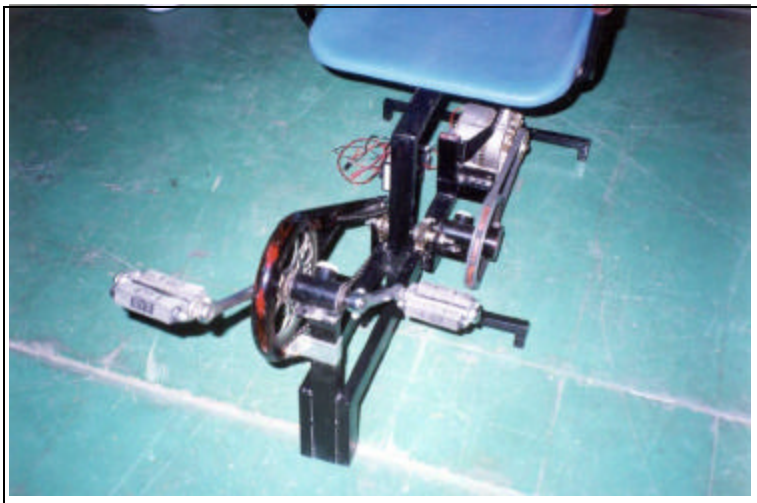
We explored a lot of different ways of lighting the schoolrooms. The requirements were quite minimal. Only lighting was the basic need. We considered solar photovoltaic, pressure kerosene lamps, liquid petroleum gas fired mantle lamps etc. Ideal would have been the photovoltaic system but it is prohibitively expensive for a common school in India. Therefore we decided to develop a pedal power generator for battery charging.

Pedal power by itself is not a new concept but is not widely used. The basic idea was to pedal at a comfortable speed and still generate enough power to make it worthwhile. We felt a ratio of 1:3 to 1:5 of pedalling time to lighting time would be encouraging enough to use this way of lighting. And we felt that this could be achieved by using compact fluorescent lamps.

First Prototype

The first prototype was developed using a car alternator. A used 40 Amp car alternator was used. The speed needed to get an output of 6 amps was over 90 rpm (at pedals). It was felt after use for about a month that this speed was pretty high and could not be maintained. A reclining chair was used for sitting. Therefore other design changes were considered. Limitations were found to be the design of generator and lighting system.

Photo on the right shows the first model.



Second Prototype

The second prototype was developed using a reclining chair but a low rpm DC motor that was originally developed for an electric bicycle. A 15-ampere diode was connected so that the battery would not drive the motor when the pedaling stopped. Pedalling speed required to achieve 6 amps output was brought down to 70 rpm. The frame was made of mild steel angles and square channels. A 40 Amp-hour battery was used to store the electricity. Two 11-watt compact fluorescent lamps were used for lighting. This model was installed in the Narmada valley and used for a year and feedback obtained. The photo on the right shows the second prototype.

- The reclining chair was not found to be most appropriate because it did not permit totally free movement of the legs.
- Students also found the load on legs irregular during pedalling, which in turn made people tired quicker.
- An indicator for battery state of charge was also felt necessary.
- Another feedback was that if the pedalling speed was reduced further then people could pedal longer.

Third Model

A Third model was made to include all the feedback received for the second prototype. The seat was changed to a standard bicycle seat and basic frame of a bicycle was used to manufacture the machine. An LED bar indicator and an ampere metre were added for state of battery and rate of charging indicator respectively. The ratios were changed so that pedalling speed was brought down to 40-60 rpm. Various experiments were done with varying sizes of flywheels and finally a flywheel was attached on the generator to balance the irregularity of pedalling force.

The above photo shows a close up of the generator and drive pulley assembly, flywheel was removed for better clarity:

Stepping-up of input pedal speed is in two stages, as mentioned earlier. A toothed belt drives the generator with 77:15 ratio pulleys. The chain stage has 16 and 44 teeth ratio, so that the overall speed step-up would be 5.133 X 2.75 = 14.12. At the chain stage (pedalling), the two sprocket wheels combination (in place of 16:44) can be varied as follows: 16:60 or 18:60 or 18:80 or 16:80 etc. These are readily available sizes in the open market in India. Other sizes would have to be custom manufactured. The 80 tooth is custom manufactured.

A brief description of parts is given in Annex 1 on page 7.

Conclusions

This is a useful machine at places where many people gather and stay together (meetings, residential schools). It is easy to maintain and make. The cost is around Rs 9,500 total, inclusive of battery (or about US $ 200).

Challenges

1. A charge controller to prevent overcharging and overuse of battery needs to be added, especially because the battery is the most expensive single part of the machine.
2. Variable speed drives would be an advantage where people of different age groups use the machines.
3. In the long run, alternative energy storage solutions would need to be designed because batteries are not the right solution, especially since they use toxic substances. Novel ways of energy storage need to be thought, without losing too much energy in transformation.

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Annexure 1

List of Major Components and brief descriptions

Bicycle Frame	Old Bicycle frames are recycled to make the basic frame of the machine. Seating arrangement and rear wheel fork is kept as is, so are the pedals, rest is cut away and a basic smithy shop is used to make the machine.
Generator	A 12 V DC, 10 Amp, four pole permanent magnet motor is used.
Drive Train	• First step-up is by a normal bicycle chain and freewheel drive. • Second step-up is achieved by toothed pulley and matching belt.
Battery	Usually a 12 V, 40 Amp-hour tubular lead-acid battery is used.
Indicators	• An LED bar level indicator with colour coded LEDs is used to indicate level of charge of battery. • A centre zero ammeter (-8A-0-+8A) is used to display charging rate.
Protection	• A 20 Amp diode is used to protect prevent current flowing to the battery when pedalling is stopped • A 20 Amp fuse is used to prevent shorting of the battery terminals

[1] Yearly Review, Central Electricity Authority, Ministry of Power, Government of India, New Delhi, www.cea.nic.in/opt3_tbl67.htm