Innovative Technique of Power Generation by Multiple Pedaling

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Abstract- 'Power generation by using multiple pedaling' is fabricated using local technology and available materials. It uses human energy to produce electricity. It's potentiality in the field of micro level electricity generation is quite significant. Here an alternator is connected to a belt-pulley and chain-sprocket arrangement in a rigid structure. The input rotation is given on the pedal and final rotational speed is obtained in the alternator rotor that consecutively produces current. A new and improved technique is developed through this project that is a single shaft can be coupled by multiple pedal which not only reduce individual's afford but also helps to generate more power by engaging more people on this work. 'Power Generator by multiple pedaling' can be an attractive renewable energy source for the production of electricity. In the developing country like ours, it can be used in the villages as useful source of power for a small family where the family members themselves can charge the battery by pedaling daily for a short period of time. It can be used for partial power supply in gymnasium, apartment, school and other public places. This will not only provide electricity according to their need but also provide a useful way of physical exercise and a handsome amount of payment to them which can be good source of income for the poor people. Due to the low manufacturing cost and very low maintenance effort, wide scale application "Power generation by multiple pedaling" can be a suitable source of renewable energy instead of solar panel. we are successful to reduce the production cost up to 30% compare to the production of solar panel.

Keywords- alternator, current, human afford, multiple pedaling, solar panel

I. INTRODUCTION

Living in 21st century, only a few recognizes the great ingenuity that is required to bring electricity in to our lives. Our proposal seeks to raise hands on awareness of electricity production, while demonstrating alternatives to the current standard in an exciting and engaging way. It is important to visualize new ways to bring power to the people as population continues to grow and power shortages continue to occur. Much of the power that is provided to people today is done in very un-sustainable ways; new ideas are needed to transition in to a post cheap-petroleum era. Electricity is one of the most important driving forces of human civilization. The main sources for producing electricity are non-renewable sources and day by day they are exhausting due to rapid growth of electricity consumption. So need for alternate renewable sources for electricity generation has become of a matter great interest. Energy cannot be created and destroyed. It can be changed from one from to another. There are many form of energy like Thermal energy, Sound energy, Kinetic energy, Potential energy, Electric energy and so one. Among them Electric energy is the most useful terminal form of energy. Using human energy can be an attractive source of small-scale electricity production. Paddle Power Generator uses this human energy to produce electricity. It is based on the alternator principle where an alternator is rotated to produce electricity and stored in a battery.

II. STRUCTURE OF MULTIPLE PEDALING UNIT

2.1 Major components-

- Rickshaw/Bicycle framework
- Chain-drive system
- Belt-pulley system for transmission
- Alternator with DC output and regulator
- Battery

2.2 Working Principal-

The entire system can be divided into three steps of energy conversion. First, the human muscle energy is converted into mechanical energy through pedaling. This mechanical energy is represented in the form of rotation of chain-sprocket system. Second, the mechanical energy is transferred through the chain drive and converted to electrical energy in the alternator. Finally, the electrical energy is stored in the battery as chemical energy.

2.2.1 Conversion of energy-

The mechanical energy is produced by the cycling action. The rotation of the larger sprocket (with the pedals) drives the smaller sprocket on the rear shaft. Motion and power are transferred with the help of a chain. The chain pulley system has a teeth ratio of 48:22. The shaft rotates and rotates a large pulley, which drives the smaller pulley of the alternator with the help of a belt drive. The belt pulley has a diameter ratio of 18:2. This ratio is chosen so to attain the charging speed of the alternator, which is around 1000 to 1200rpm. This reduces pedaling effort. Conversion from mechanical energy to electrical energy is done with the help of an automotive alternator. An alternator is simply an electromechanical device used to convert mechanical energy to electrical energy in the form of alternating current. Since battery charging needs DC voltage, a rectifier is used to convert the AC current to DC current. This is done by the battery. As the alternator generates the charging voltage, terminals of the battery connected to the alternator draws in charging current and the battery charges itself, and stores the energy in chemical form. The typical chemical reaction that occurs in an automotive lead-acid battery (similar to one used in experiment) is shown below-

$$PbO_2 + Pb + 2H_2SO_4 \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftarrows}} 2PbSO_4 + 2H_20$$

2.3 Main Structure

The main structure consists of two bicycle frameworks for two users to pedal simultaneously. The frameworks are placed parallel to each other and connected by a rod. The rod improves stability and vibration of the whole structure. The framework is been welded to horizontal angle bars for support. Chain drive transfers power to the shaft. Free-wheeling sprockets on the shaft allow two users to pedal simultaneously or individually. The shaft also has a large pulley that is connected to the alternator via a belt drive system. The alternator can be moved horizontally along the parallel setup to loosen or tighten the belt, or to remove it if the belt wears out. It also allows greater flexibility in selecting the length of the belt.

(a) (b)

Figure. 1. (a) proposed design; (b) actual design

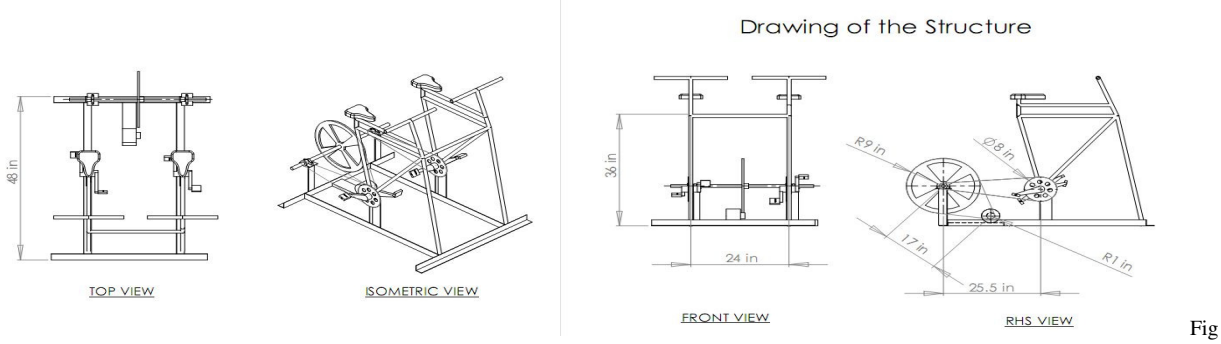


Figure 2. detail drawing of the structure

2.4 Technical parameters-

Table 1. Technical specification

No	Feature	Dimension / specification
1.	Overall Dimension	48 inch X 24 inch X 48 inch
2.	Diameter of Large pulley	18 inch
3.	Diameter of small pulley	2 inch
4.	Teeth no of Large sprocket	48
5.	Teeth no of small sprocket	22
6.	Centre Distance between pulley	17 inch
7	Height of hand rest	48 inch
8.	Speed multiplying factor	19.63

9.	Alternator Driving belt	Belt No: A 68
10.	Storage Battery	Brand : Non brand , 35 AHr-12V Battery
11.	Alternator	60 Amp-12V, Automotive type.

2.5 Power transmission-

The design of the system is such that there are two stages of power transmission needed to reach the minimum effective charging speed of the alternator. The first transmission occurs by a chain-sprocket system and the second by a belt-pulley system which in turn is connected to a single rotating shaft. When the user pedals, the large sprocket is rotated at a speed equal to the rotation of the pedal. This large Sprocket has 48 teeth. The large sprocket is connected by a chain to the small sprocket of 22 teeth.

Let the large sprocket rotate at a speed N_1 and the small sprocket rotate at a speed N_2. So the relation of the rotation of the two sprockets is-

$$\frac{N_2}{N_1} = \frac{48}{22} \qquad (1)$$

Now the small sprocket has the same shaft with the large pulley of the belt pulley system. So the large pulley rotates at the same speed as the small sprocket. So if the speed of the large pulley is N_3 then-

$$N_2 = N_3 \qquad (2)$$

Here diameter of the large pulley is 18 in and small pulley is 2 in; let the speed of the small pulley is N_4. So

$$\frac{N_4}{N_3} = \frac{18}{2} \qquad (3)$$

Now as the small pulley is coupled with the alternator so the speed of the small pulley will ultimately be the speed of the alternator. Form equation 1, 2 and 3 speed of the alternator

$$\frac{N_4}{N_1} = \frac{48}{22} \times \frac{18}{2} = 19.63$$

Therefore, the ultimate speed multiplying factor = 19.63
If pedal rpm is 60, then alternator rpm becomes 60x19.63 = 1177.
Rpm are calculated and verified using a contact-type tachometer.

2.6 Belt pulley selection-

Known data,
Diameter of Larger pulley, d_1 = 18 in = 45.72 cm
Diameter of small pulley, d_2 = 2 in = 5.08 cm
Centre distant between two pulley, c = 17 in = 43.18 cm

Then, length of the belt, $L = \frac{\pi}{2}\left(d_1 + d_2\right) + 2c + \frac{(d_1 - d_2)^2}{4c}$

= 176 cm (~70in)

III. RESULTS

Charging an automotive battery is the primary goal of this Alternating power generator. This setup is used to charge a battery up to a certain level in relation to the electrical power consumed from the battery. To determine the exact state of the battery for desire charging level, the following parameters need to be known.

- Rotational speed of the alternator rotor.

- Generated voltage and current from the alternator.
- Open circuit voltage (OCV) of the battery.
- Specific gravity of the battery electrolyte

The performance test results regarding various parameters, data table and graphs are shown below.

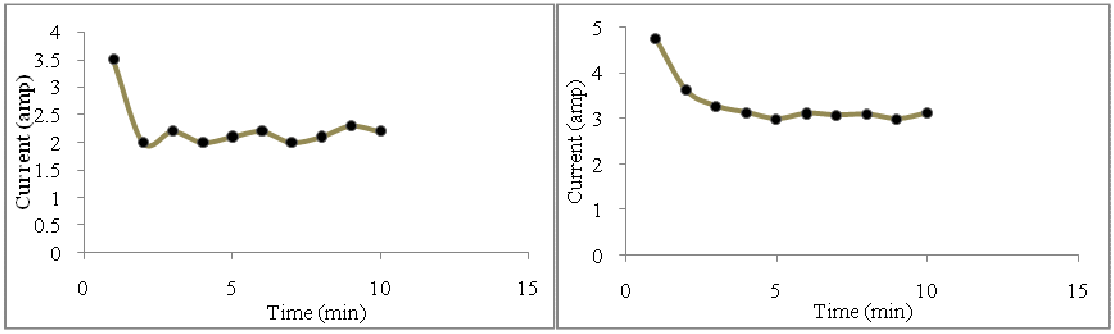
Table 2.1 Observation for a single person pedaling

Obs NO:	Time(min)	Voltage(Volt)	Avg Voltage (Volt)	Current (amp)	Power (Watt)
1	1	12.38-12.45	12.41	3.5	43.57
2	1	12.36-12.62	12.49	2	25.24
3	1	12.58-12.70	12.64	2.2	27.94
4	1	12.57-12.75	12.66	2	25.5
5	1	12.64-12.80	12.72	2.1	26.88
6	1	12.72-12.78	12.75	2.2	28.05
7	1	12.75-12.79	12.77	2	25.54
8	1	12.74-12.78	12.76	2.1	26.8
9	1	12.78-12.92	12.85	2.3	29.55
10	1	12.75-12.86	12.80	2.2	28.17

Table 2.2 Observation for double person pedaling

Obs NO:	Time(min)	Voltage(Volt)	Avg Voltage (Volt)	Current (amp)	Power (Watt)
1	1	12.32-12.52	12.42	4.75	58.9
2	1	12.38-12.64	12.51	3.63	45.4
3	1	12.56-12.68	12.62	3.28	41.1
4	1	12.58-12.72	12.65	3.14	39.7
5	1	12.62-12.78	12.70	3.00	38.1
6	1	12.66-12.76	12.71	3.12	39.6
7	1	12.69-12.78	12.73	3.08	39.2
8	1	12.72-12.80	12.76	3.10	39.5
9	1	12.75-12.84	12.79	3.00	38.3
10	1	12.78-12.85	12.81	3.13	40.1

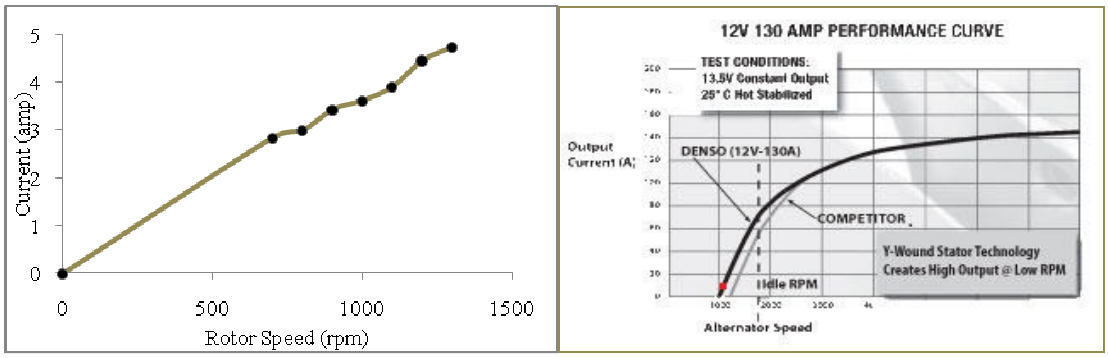
Initially there is a large amount of current flow which is known as surge current. As time passes current become stable and power varies with the current flow. Terminal Voltage varies with current and if the battery is fully charged then it with show approximately 12.80 volt. For a single person rotor speed varies from 700-1000 rpm. And in the observation current varies from 3.5-2 amp.



(a) (b)

Figure. 3.(a) Charging current Vs Time (single person); (b) Charging current Vs Time (Two person)

Charging current varies with rotor speed. As the alternator's rated rpm is 3000rpm but in this project maximum rotor speed recorded was 1350 rpm. Charging current are recorded for the rotor speed varies from 700 rpm to 1350 rpm and the corresponding current varies from. The recorded data are given below.



(a) *(b)*

Figure.4. (a)Charging current Vs Rotor Speed; (b) performance curve of a typical alternator

Power obtained by a single person and two persons are given below.

Table 3. Power output for single person and two person

Output Power (Watt) Single Person	Output Power (Watt) Two person
43.57	58.9
25.24	45.4
27.94	41.1
25.50	39.7
26.88	38.1
28.05	39.6
25.54	39.2
26.80	39.5
29.55	38.3

IV. COMPARISON WITH SOLAR PANEL

Table 4. Cost analysis

Components		Price (USD)
Structure		
	Frame	15
	Axle	10
	Pulleys, sprockets and chains	12
	Angle Bar (17.5 kg)	15
	Accessories	10
Alternator		35
Battery		30
Total		$ 127

Table 5. cost comparison

Power Source	Cost (USD) Per watt
Solar Energy	7.79
Human Power	4.23

V. DISCUSSION AND CONCLUSION

Human power generation can be an attractive renewable source as far as small-scale production of electricity is concerned. Although, initially it may not be popular to city-dwellers where electricity is available at a much cheaper rate and consumption is huge, the prospect of using human power generation in rural areas is brighter, where electricity is scarce and often completely unavailable. This system can, under such circumstances, help produce enough electricity for lighting individual homes at a village. Also, the concept of multiple pedaling can reduce the physical effort needed and charging time, which are vital in rural areas where agrarian life often demands human energy for other uses, such as farming. Other fields of application of this pedal-powered generator may include supplying necessary amount of electricity during long term load-shedding, charging small electronic equipments and so on. Another interesting use can be powering and charging portable research equipments in isolated and inhospitable places, such as in the arctic region or the jungle. In that case, the design needs to be adapted for portability, since the current design is quite bulky. The preliminary studies on the paddle power generator are encouraging as the system has a low cost when compared to a solar photovoltaic home system of similar energy output. Also materials needed to make the setup are available and fabrication is quite simple; maintenance required is therefore low.

REFERENCES

[1] Khurmi, R.S. and Gupta, J.K.,*Theory of Machines,* S' Chand & Co, New Delhi, India.
[2] Crouse, W.H. and Angline, D.L., *Automotive Mechanics*, Tata Mcgraw-Hill,New Delhi, India.
[3] Theraje, B.L. and Theraje, A.L., E*lectrical Machines*, S' Chand & Co, New Delhi, India.
[4] Hannah, J. and Stephens, R.C., *Mechanics of Machines*, Viva Books Private Ltd, Mumbai, India.
[5] World Energy Council Report 2007, *Deciding the future: Energy Policy Scenario 2050*