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Research Article

Experimental Investigation and Performance Analysis of Oscillatory Power Producer for Operating Electric Vehicles

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Abstract

The sustainable energy sources provide an alternative for generation of power for the upcoming generations due to the problem of reduction of the fossil fuels. This paper upgrades the usage of sustainable power hotspots for everyday applications. It includes the model demonstrating of a power maker utilizing wind as a significant origin of energy and piezoelectric cells as an arbiter way between the oscillator and load for converting mechanical oscillations into power. Additionally, it shows the variety in the power creation when contrasted with the regular level horizontal turbine structure. The model has been tried with a particular application indicating the viable power creation with the oscillatory wind based framework. Additionally battery has been utilized as an energy storage device, which gives the vitality if there should arise an occurrence of breaks from the source. The proposed model has likewise been tried with various breeze speed conditions, various loads ON, OFF conditions.

Keywords: Oscillatory Power Producer; Piezoelectric Cells; Battery

Introduction

The renewable energy source is an inexhaustible asset that can be utilized over and over and doesn't run out on the grounds that it is normally supplanted. An inexhaustible asset, basically, has an interminable gracefully, for example, sunlight based vitality, wind vitality, and geothermal pressure. Wind is the most popular source which is available freely, about all the day. For instance, windmills tackle the breeze's regular force and transform it into energy. Horizontal-hub wind turbines [1-3] are considerably more generally utilized, regardless of whether it requires a system for situating the sharp edges. This sort of air generators is described by a higher streamlined yield than the vertical one. Besides, it begins self-rulingly and has low components at the ground level.

In fact, level hub wind turbines depend on the familial breeze. They are comprised of a few sharp edges that are efficiently formed like plane wings. For this situation, lift isn't utilized to keep up an airplane in flight, yet for producing a driving torque causing revolution. The quantity of sharp edges utilized for electric force age normally differs somewhere in the range of 1 and 3; with three cutting edges, there is a tradeoff between the force coefficient, the expense, and the speed of turn of the breeze sensor. These wind turbines face certain disadvantages such as taller poles and cutting edges are increasingly hard to move and introduce. Transportation and establishment would now be able to cost 20% of hardware costs [4-5]. More grounded tower development is required to help the overwhelming sharp edges, gearbox, and generator. Reflections from tall HAWTs may influence side flaps of radar establishments making signal mess, in spite of the fact that sifting can smother it. Pole stature can make them prominently obvious across enormous regions, disturbing the presence of the scene and in some cases making nearby resistance. Downwind variations experience [6] the ill effects of weariness and basic disappointment brought about by choppiness when a sharp edge goes through the pinnacle's breeze shadow (consequently, most of HAWTs utilize an upwind plan, with the rotor confronting the breeze before the pinnacle). They require an extra yaw control component to turn the cutting edges toward the breeze.

Vortex actuated vibrations is a law of producing power utilizing vibrations framed encompassed by the structure when air or liquid disregards the course of action. Inferable from which power will be created inside the structure and afterward the structure dislodges [7]. The displacement of the structure can be changed in to electrical force utilizing certain power takeoff techniques. To convert the dislodgement of the structure, piezoelectric conversion has been chosen. Piezoelectric materials can work at any temperature conditions. They have low carbon impression making them the best option for non-renewable energy source. Unused vitality lost as vibrations [8-10] can be tapped to create environmentally friendly power vitality and these materials can be reused. The battery storage system will allow the energy flow from the source to the load in the load ON condition and in the source OFF condition; the power flow will be energized [11-15] from the battery to the load and in the load OFF condition, the energy will flow from the source to the battery. The work enhances the usage of wind using new oscillatory technology involving less cost, less maintenance and no noise.

The paper is structured as follows; the first division of the paper is dealing with the experimental setup of proposed oscillatory power producer. The second section presents with the effect of variable wind speeds on the power generation and the third part discusses with the Performance study of battery, and the last part deals with the conclusion.

Experimental setup

The experimental setup of the oscillatory power producer has been shown in the below figure. The prototype consists of tapered cylindrical mast diode bridge rectifier, lead acid battery, spring; transformer based full bridge inverter, diode bridge rectifier and piezoelectric cells. The experiment was conducted to observe the response of voltage, current, power with respect to varying wind speeds. A range of wind speeds from U=0 to15m/s was considered for conducting experiment with a mast of length of 0.5m, spring in between the piezoelectric cells and the mast for increasing the oscillations of the mast.

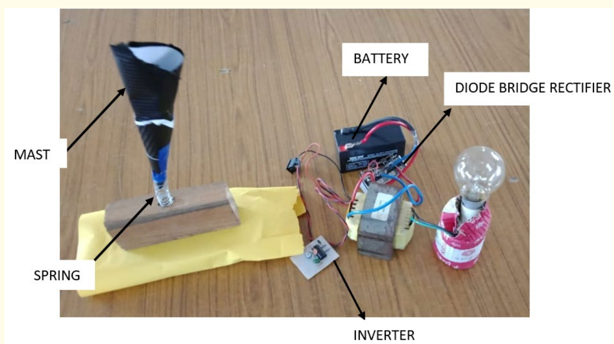

Figure 1: Experimental setup of oscillatory power producer.

Effect of variable wind speeds on the power generation

The analysis was performed at different breeze speeds running from 1.0m/s to 10m/s underneath the piezoelectric cells. At the point when the breeze disregards the pole, it begins swaying with certain relocation, at that point the piezoelectric cells underneath the pole experience stress because of which AC energy will be produced at the terminals of the piezoelectric cells. The yield at the piezoelectric cells will be taken care of to the diode connect rectifier which changes over the AC vitality into DC vitality which is legitimately taken care of to the lead corrosive battery. The vitality from the battery will be taken care of to the load with the load ON condition through charging state.

Variable Wind Speeds (0<U<5m/s)

The wind speed was varied from U= 0 to 5m/s and its respective voltage, current, power have been noted and the below curves shows the variation of these parameters for different wind speeds. For increasing wind speeds, increase in the voltages, currents can be observed with change in the power generated. But the difference in the change in the values of parameters like voltage, current, power is very small. The power generation values states that the entering of the power producer into cut in region generating power even which is not possible in the conventional horizontal axis wind turbine. The below figure shows the voltage Vs current characteristics of the proposed power producer for various wind speeds. For wind speed of U=1m/s, the model was generating the voltage of around 5V, wind speed of U=2m/s, the model was generating the voltage of around 7.1V, wind speed of U=3m/s, the model was generating the voltage of around 8V, wind speed of U=4m/s, the model was generating the voltage of around 13V, wind speed of U=5m/s, the model was generating the voltage of around 14.6V, where the battery gets charged with the voltage and also it attains the maximum current of 8A.

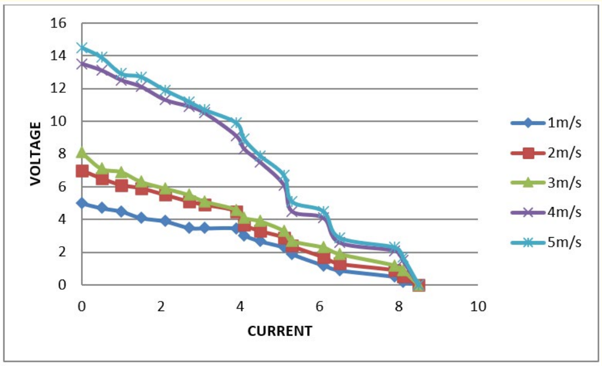

Figure 2: Voltage Vs current characteristics of power producer ((0<U<5m/s)).

The below figure shows the power Vs current characteristics of the proposed power producer for various wind speeds. For wind speed of U=1m/s, the model was generating the power of around 14W, wind speed of U=2m/s, the model was generating the power of around 16.5W, wind speed of U=3m/s, the model was generating the power of around 17.9W, wind speed of U=4m/s, the model was generating the power of around 20W, wind speed of U=5m/s, the model was generating the power of around 23W, with a maximum current of around 8A.

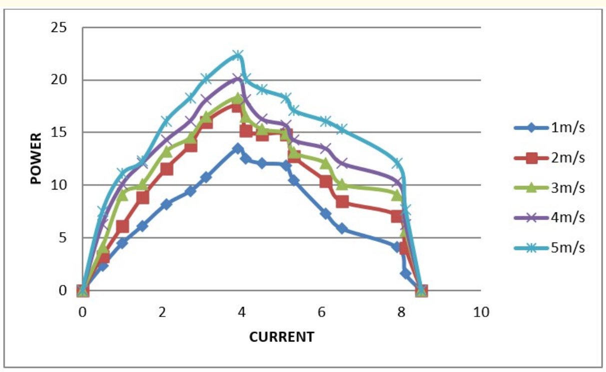

Figure 3: Power Vs current characteristics of power producer ((0<U<5m/s)).

Variable Wind Speeds (5<U<10m/s)

The wind speed was varied from U=6 to 10m/s and its respective voltage, current, power have been noted and the below curves shows the variation of these parameters for different wind speeds. For increasing wind speeds, increase in the voltages, currents can be observed with change in the power generated. The below figure shows the voltage Vs current characteristics of the proposed power producer for various wind speeds. For wind speed of U=6m/s, the model was generating the voltage of around 16.2V, wind speed of U=7m/s, the model was generating the voltage of around 19.3V, wind speed of U=8m/s, the model was generating the voltage of around 20.1V, wind speed of U=9m/s, the model was generating the voltage of around 25V, wind speed of U=10m/s, the model was generating the voltage of around 35V, where the battery gets charged with the voltage and also it attains the maximum current of 8A.

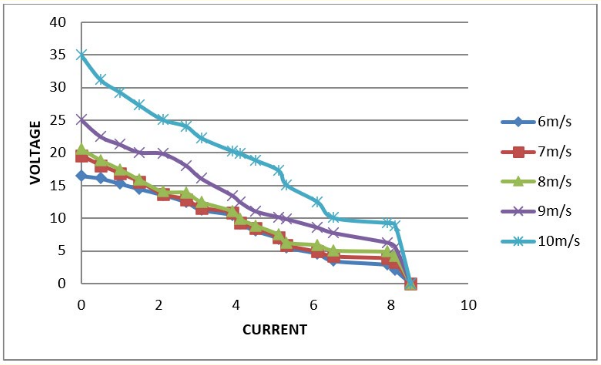

Figure 4: Voltage Vs current characteristics of power producer ((5<U<10m/s)).

The below figure shows the power Vs current characteristics of the proposed power producer for various wind speeds. For wind speed of U=6m/s, the model was generating the power of around 60W, wind speed of U=7m/s, the model was generating the power of around 63W, wind speed of U=8m/s, the model was generating the power of around 65W, wind speed of U=9m/s, the model was generating the power of around 70W, wind speed of U=10m/s, the model was generating the power of around 107W, with a maximum current of around 8A.

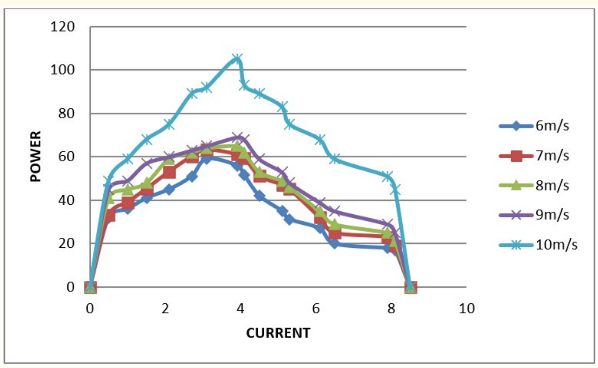

Figure 5: Power Vs current characteristics of power producer ((5<U<10m/s)).

Variable Wind Speeds (10<U<12m/s)

The wind speed was varied from U=11,12m/s and its respective voltage, current, power have been noted and the below curves shows the variation of these parameters for the two wind speeds. For increasing wind speeds, increase in the voltages, currents can be observed with change in the power generated. The below figure shows the voltage Vs current characteristics of the proposed power producer for various wind speeds. For wind speed of U=11m/s, the model was generating the voltage of around 35V, wind speed of U=12m/s, the model was generating the voltage of around 35.1V.

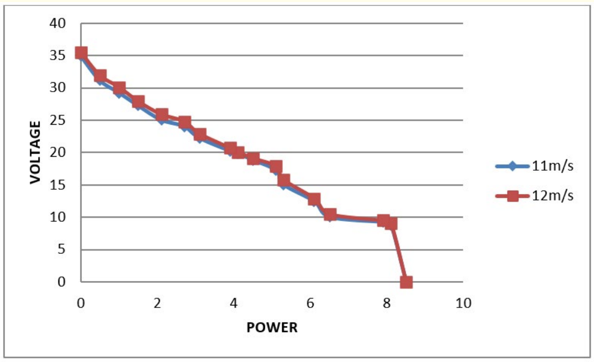

Figure 6: Voltage Vs current characteristics of power producer (10<U<12m/s).

The below figure shows the power Vs current characteristics of the proposed power producer for various wind speeds. For wind speed of U=11m/s, the model was generating the power of around 107W, wind speed of U=12m/s, the model was generating the power of around 108W.

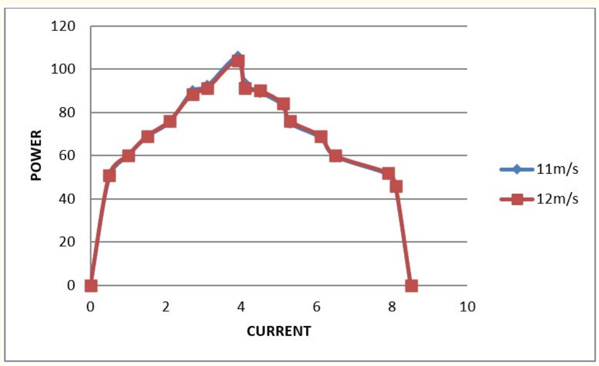

Figure 7: Power Vs current characteristics of power producer (10<U<12m/s).

From the above assessment, it can be concluded that the oscillatory power producer is able to generate power of 105W, with a voltage of 35V, with a current of 8A which can be collected at the output terminals of the piezo electric cells. The output of the piezoelectric cells is fed to the diode bridge converter converting the AC output of the piezo generator into DC which then fed to the battery. As it can be observed from the graphs that wind speeds from U=0 to U=12m/s, the operation of the proposed oscillatory based power producer can be divided into three regions. From U=0 to 1m/s, the power producer generates negligible power, from U=1 m/s, the power producer generates certain power stating cut in speed of the turbine, from U=2 m/s to U=10 m/s, the power producer generates certain power stating rated speed of the turbine and from U>10 m/s, the power producer generates constant power stating cutout speed of the turbine.

Effect of variable wind speeds on the charging state of battery

The output of the diode bridge rectifier has been fed to the battery of 12V, 7.2Ah capacity for storage purpose in load OFF condition. For various wind speeds from U=0 to U=15m/s, the battery charging profile has been given below and from U=0 to 7m/s, the charging state increases linearly with respect to the wind speed and from U=7 to 10m/s, the charging state increases with a very less change with respect to the wind speed and from U=10 to 12m/s, the charging state almost remains constant with respect to the wind speed and after U= 12m/s, the charging state remains constant stating fully charged condition.

WIND SPEED (U)	*BATTERY VOLTAGE(V)*
0m/s	0.1
1m/s	5
2m/s	7
3m/s	8.1
4m/s	13.5
5m/s	14.5
6m/s	16.5
7m/s	16.8
8m/s	17.1
9m/s	17.5
10m/s	17.9
11m/s	18.5

Table 1: Wind Speed Vs Battery Voltage Values.

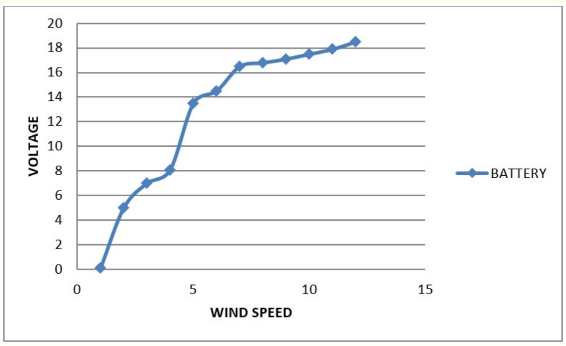

Figure 8: Voltage Vs wind speed characteristics of battery.

Performance study of battery

The performance of the battery like charging nature, discharging nature has been tested with different conditions like Load ON condition-source ON condition, Load ON condition-source OFF condition, Load OFF condition-source ON condition, Load OFF condition-source OFF condition.

Load ON condition-source ON condition

The battery state has been tested with turning ON both the load, source condition. So wind speed as a source, the oscillatory power producer generating certain voltage which charges the battery. Then the power flow from the battery to the inverter and then to the load which is considered as a bulb. So simultaneous actions like charging of the battery and then supply of the power to the load through the battery will occur. So as the battery charges, in the same manner the load also attains the power.

U	*BATTERY(V)*	*LOAD(V)*
0m/s	0.1	0
1m/s	5	4.5
2m/s	7	6.9
3m/s	8.1	7.9
4m/s	13.5	13.1
5m/s	14.5	14.3
6m/s	16.5	15.5
7m/s	16.8	16.1
8m/s	17.1	16.8
9m/s	17.5	17.1
10m/s	17.9	17.5
11m/s	18.5	18.1

Table 2: Wind Speed Vs Battery Voltage Vs load Values (Load ON condition-source ON condition).

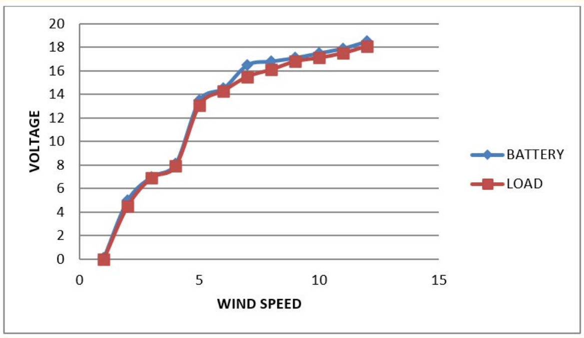

Figure 9: Voltage Vs wind speed characteristics of load and battery (Load ON condition-source ON condition).

Load ON condition-source OFF condition

The battery state has been tested with turning ON the load, but turning OFF the source condition. So considering the absence of wind speed, the output from the oscillatory power producer is zero and the load runs through the charged battery. Then the power flow from the battery to the inverter and then to the load which is considered as a bulb.

U	BATTERY	LOAD
0m/s	17.5	0.05
0m/s	17.3	4
0m/s	17.1	6
0m/s	16.7	8
0m/s	16.6	13.1
0m/s	16.5	13.5
0m/s	16.5	15.5
0m/s	16.3	15.5
0m/s	15.1	16.1
0m/s	14.9	16.5
0m/s	14.3	17.1
0m/s	14.1	17.3

Table 3: Wind Speed Vs Battery Voltage Vs load Values (Load ON condition-source OFF condition).

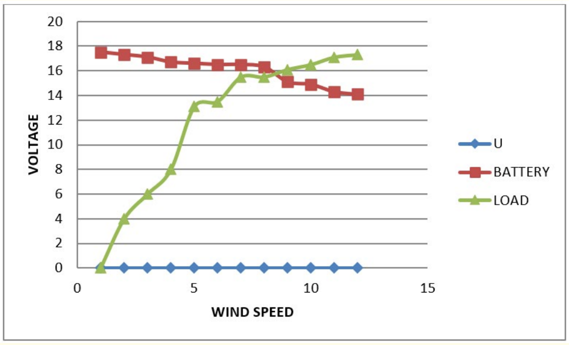

Figure 10: Voltage Vs wind speed characteristics of load and battery (Load ON condition-source OFF condition).

Load OFF condition-source ON condition

The battery state has been tested with turning OFF the load, but turning ON the source condition. So considering the absence of load, the output from the oscillatory power producer charges the battery.

U	*BATTERY*	*LOAD*
0m/s	0.1	0
1m/s	5	0
2m/s	7	0
3m/s	8.1	0
4m/s	13.5	0
5m/s	14.5	0
6m/s	16.5	0
7m/s	16.8	0
8m/s	17.1	0
9m/s	17.5	0
10m/s	17.9	0
11m/s	18.5	0

Table 4: Wind Speed Vs Battery Voltage Vs load Values (Load OFF condition-source ON condition).

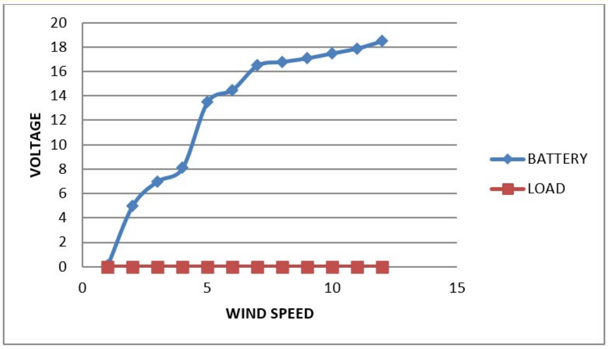

Figure 11: Voltage Vs wind speed characteristics of load and battery (Load OFF condition-source ON condition).

Load OFF condition-source OFF condition

The battery state has been tested with turning OFF both the load, source condition. So the wind speed is zero and also load is OFF, then the battery voltage remains almost constant.

U	*BATTERY*	*LOAD*
0m/s	17.1	0
0m/s	17.2	0
0m/s	17.2	0
0m/s	17.2	0
0m/s	17.3	0
0m/s	17.5	0
0m/s	17.5	0
0m/s	17.5	0
0m/s	17.5	0
0m/s	17.5	0
0m/s	17.5	0
0m/s	17.5	0

Table 5: Wind Speed Vs Battery Voltage Vs load Values (Load OFF condition-source OFF condition).

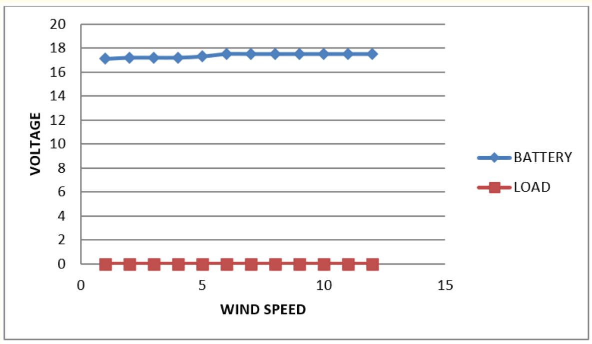

Figure 12: Voltage Vs wind speed characteristics of load and battery (Load OFF condition-source OFF condition).

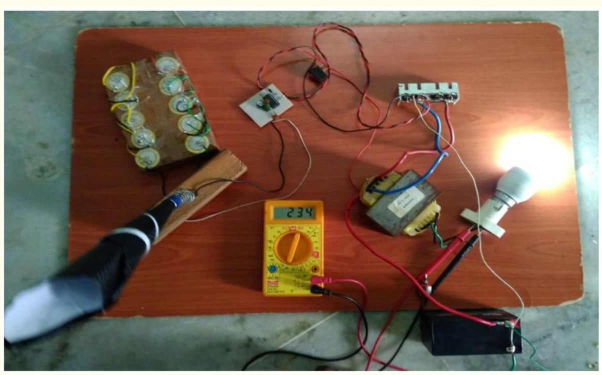

Figure 13: Experimental Set up with application.

Conclusions

The experimental investigation of the proposed oscillatory power producer has been presented in this paper. It involves the study of the power producer at different wind speeds, different charging states of the battery and also load ON, OFF conditions. The results shows that the proposed power producer generates certain amount of power at U=1m/s which is not possible for the conventional wind turbine and also provides better power and voltage characteristics. It was concluded that the proposed power producer can be a solution for reducing the disadvantages of conventional wind turbine like noise, higher investment, and higher maintenance.

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