Performance Evaluation of the Development of Micro Wind Turbine

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***Abstract*—Wind turbine, which produced virtually no CO_2 emission and generates mainly green energy, has long been recognized as an abundant potential source of electric power and the fact that wind power is one of the lowest cost power generation technologies. In this case a micro wind turbine was developed, its measurement, results and analysis are been presented in this work. The performance evaluation has been carried out successfully. The turbine which comprises of three blades made of pipe, a DC dynamo used in place of an electric motor, a DC to AC converter, a hub that holds the blades, a vertical hollowed shaft, nacelle that holds at the centre of the turbine. A four yards length of electric wire is also used. This work was developed base on proper application of some factors that will aid the smooth running of the system. The factors which include: the weather condition, location, properties of materials used, satisfactory performance of mechanism, economic consideration. A test was carried out on the wind turbine. The whole setup was placed on a surface of high altitude. After few seconds, the blade rotates and the multimeter was connected to it in order to read the value for the current and the voltage. The average value of the power output was 0.095 Watt in respect of the current and the voltage obtained**

***Keywords*—Wind,Turbine, Power, Performance, Evaluation.**

I. INTRODUCTION

Wind can be defined as air in motion. The differences in temperature lead to differences in pressure which in turn causes air to move from place to place. Therefore, we experience these movements as the blowing of the wind (Holmes, 2011). The kinetic energy of the wind can be changed into other forms of energy, either mechanical energy or electrical energy. The wind turbine is a structure or machine that converts wind power into usable energy through the rotation of a made up of adjustable blades (Advameg, 2011).

The wind power is the conversion of wind energy into useful form. Wind power is produced in a large scale wind farms connected to electrical grids, as well as in individual turbines for providing electricity to isolated locations (Gipe, 2006). Globally, wind power generation increased more than fivefold between 2000 and 2007 (David, 1998).

The first use of a large windmill to generate electricity between 5kW to 25kW was a system built in Cleveland, Ohio, USA (Maxwell, 2007). In 1888 Charles F. Brush built machine which was a post mill with multi-blade “picket-fence” rotor 17 meters in diameter, featuring a large tail hinged to turn the rotor of the wind. It was the first wind mill to incorporate step up gear box (with a ratio 50:1) in order to turn a direct current generator at its required operational speed (in this case 500 rpm), (Halladay, 2002)

In 1891, the Dane Poul la Cour developed the first electrical output wind machine to incorporate the aerodynamic design principle (low- solidity, four bladed rotors incorporating primitive air foil shapes) used in the European tower mills. By the end of World War I, the use of 25kW electrical output machine had spread throughout Denmark, but cheaper and larger fossil-fuel steam plants put the operators of these mills out of business (Canadian wind Energy Association, 2001)

By 1920, two dominant rotor configurations (fan-type and sail) had both been tried and found to be inadequate for generating appreciable amount of electricity. The further development of wind generator systems in United State was inspired by the design of airplane propellers and (later) monoplane wings (America Wind Energy Association, 2008).

Large wind turbines most often used by utilities to provide power to a grid, range from 250 kW up to the enormous 3.5 to 5 MW machines that are being used off shore (Wailes, 1981). Today, the average land anywhere from 50 to 100 meters tall, and has blades. It can be considered that variability of wind to be a fatal problem. In a large utility system, the variations in power output from wind turbines are in the most typical designs; the blades are attached to an axle that runs into a gearbox (Patrick, 1995).

All winds turbines are generally used for providing power off the grid, ranging from very small, 250 watts turbines signed for charging up batteries on a sailboat, to 50 kilowatt turbines that power dairy farms and remote villages. Axe old farm windmills, these small wind turbines have tail fans that keep them oriented into the wind. Fig.1 shows the example of wimdmills.

Fig.1: Windmills (Corbis, 2009).

II. MATERIALS AND METHODS

Wind Turbine Power Coefficient

The amount of power transferred to a wind is directly proportional to the density of the air, the area swept out by the rotor, and the cube of the wind speed.

The usable power P available in the wind is given by the equation (1):

$$P = \frac{1}{2} \propto \rho \pi r^2 v^3 \quad (1)$$

Where:

P = power in watts

$\propto$ = an efficiency factor determined by the design of the turbine

ρ = Mass density of air in Kilograms per cubic meter,

$$\text{Density} = \frac{\text{mass}}{\text{volume}} \quad (2)$$

r = radius of the wind turbine in meters, and

v = velocity of the air in meter per second m/s

This equation shows the effects of the mass rate of flow of air travelling through the turbine, and the energy, if each unit mass of air flow due to its velocity. As an example on a cool 15^{o}C day at sea level air density is 1.225 kilograms per cubic meter. An 8m/s (28.8 km/h) breeze blowing through a 100meter diameter rotor would move almost 77,000 kilograms of air per second through the swept area. The total power of the example breeze through a 100 meter diameter rotor would be about 2.5 megawatts. Betz's law states that no more than 1.5 megawatts could be extracted. (Douglas et al, 2001).

Determination of the Power, P

Power available in the wind $= \frac{1}{2} \times$ air density $\times$ swept area $\times$ wind velocity^3 (Douglas, 2003) (3)

Air density at sea level = 1.23 kg/m^3 (Baker, 1985)

Swept area = πR^2, R = 540 mm = 0.54 m

Average wind velocity = 4 m/s

Wind power at average wind speed $= 0.5 \times 1.23 \times \frac{22}{7} \times 0.54^2 \times 4^3 = 36.1$ Watts

For the highest wind velocity recorded which is 11.1 m/s

Wind power$= 0.5 \times 1.23 \times \frac{22}{7} \times 0.54^2 \times 11.1^3 = 770.8$ Watts

This is the maximum power in the wind. However, it is impossible to harvest all the power in the wind according to the Betz limit. The Betz limit tells us that the percentage of power we can harvest from the wind is 59.26%.

Therefore, electrical power to be gotten at average speed $= 0.5926 \times 36.1 = 21.4$ Watts

At the highest speed of 11.1 m/s, the electric power to be gotten $= 0.5926 \times 770.9 = 456.8$ Watts

The following data were obtained using a multimeter to measure the current and the voltage

Table 1: Testing Data

S/N	Time interval, t (secs)	Current, I (A)	Voltage output, V (V)
1	5	0.030	0.37
2.	10	0.029	0.32
3.	15	0.034	0.39
4.	20	0.017	0.14
5.	25	0.021	0.18
6.	30	0.034	0.39
7.	35	0.040	0.43
8.	40	0.027	0.30
9.	45	0.030	0.37
10.	50	0.034	0.39

$$P = IV \quad (4)$$

Table 2 : Power Generated

S/N	Current, I (A)	Voltage output, V (V)	Power, P (W)
1	0.030	0.37	0.011
2.	0.029	0.32	0.009
3.	0.034	0.39	0.013
4.	0.017	0.14	0.002
5.	0.021	0.18	0.004
6.	0.034	0.39	0.013
7.	0.040	0.43	0.017
8.	0.027	0.30	0.008
9.	0.030	0.37	0.011
10.	0.034	0.39	0.013

III. RESULTS

Test was carried out at time intervals; the multimeter was measuring the current and the voltage simultaneously. The reading was recorded as is given in table 1. The data obtained using a multimeter to measure the current and the voltage were used to calculate power output of the micro wind turbine using equation (4) as shown in table 2.

Table 3: Results

S/N	Time interval, t (secs)	Current, I (A)	Voltage output, V (V)	Power, P = IV (W)
1	5	0.030	0.37	0.011
2.	10	0.029	0.32	0.009
3.	15	0.034	0.39	0.013
4.	20	0.017	0.14	0.002
5.	25	0.021	0.18	0.004
6.	30	0.034	0.39	0.013
7.	35	0.040	0.43	0.017
8.	40	0.027	0.30	0.008
9.	45	0.030	0.37	0.011
10.	50	0.034	0.39	0.013

IV. DISCUSSION

The results were shown in table 3 and graphically represented in fig. 2 to 7.

Fig. 2 shows the graph of voltage against time at 15, 30 and 50 secs the voltage is 0.39 V. At 35 secs the multimeter gives the highest voltage, 0.43 V.

Fig. 3 shows the graph of current against time at 15, 30 and 50 secs the current is 0.034 A. At 35 secs the multimeter gives the highest current, 0.040 A.

Fig. 4 shows the graph of power against time at 15, 30 and 50 secs the power is 0.013 Watt. At 35 secs the multimeter gives the highest power, 0.017 Watt.

Fig. 5 shows the graph of voltage against current, when the voltage is 0.43 V, the highest current, 0.040 A is produced

Fig. 6 shows the graph of voltage against current, when the voltage is 0.43 V, the highest power, 0.017 Watt is produced

Fig. 7 shows the graph of voltage against current, when the voltage is 0.040 V, the highest power, 0.017 Watt is produced

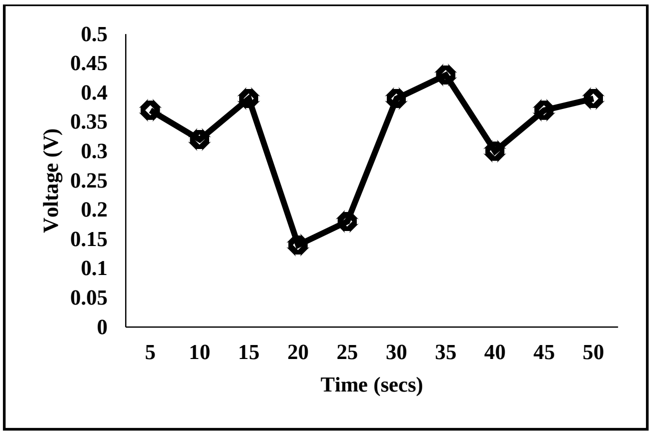

Fig. 2: Voltage against Time

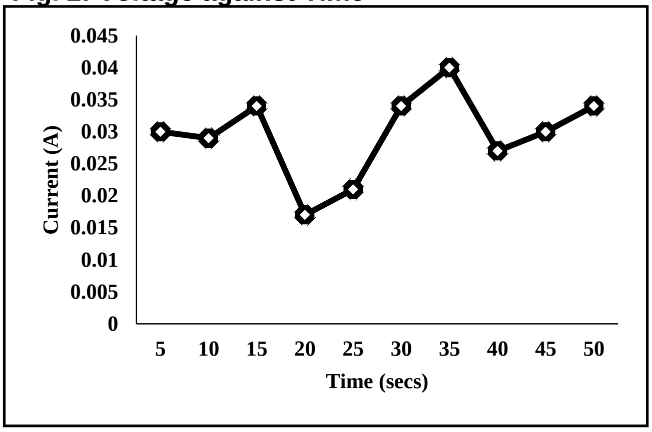

Fig. 3: Current against Time

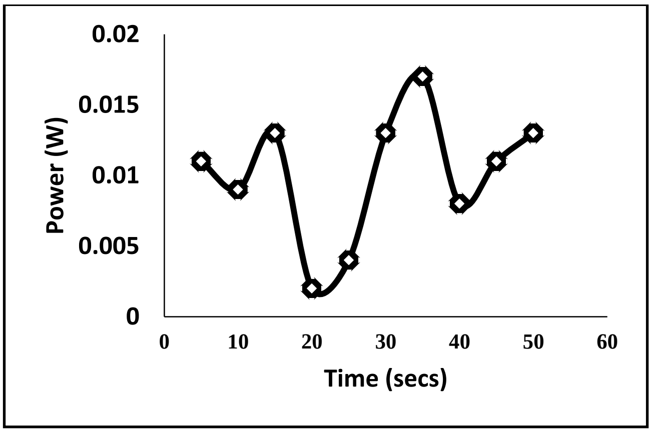

Fig. 4: Power against Time

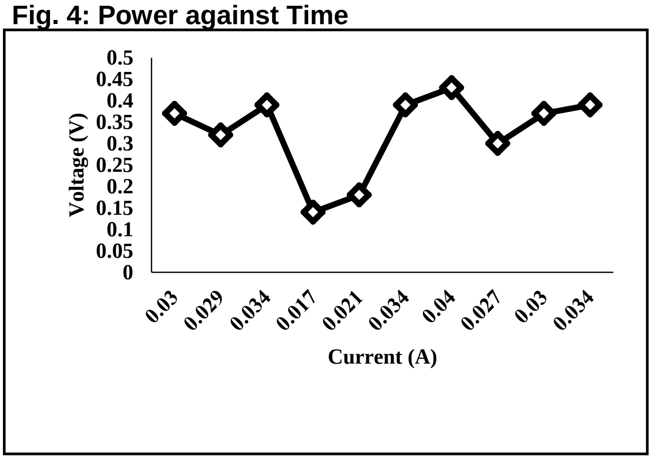

Fig. 5: Voltage against Current

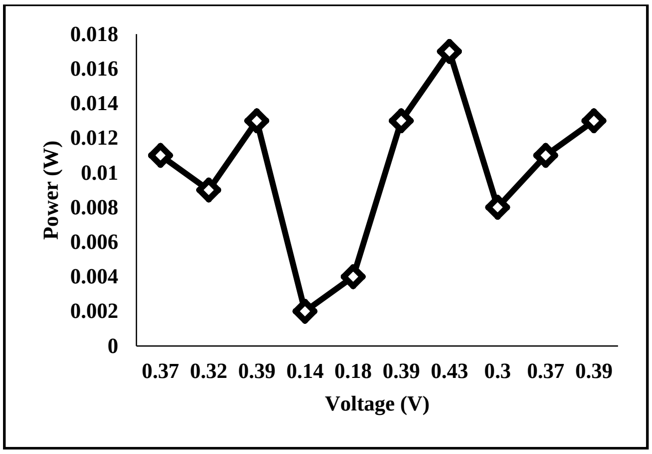

Fig. 6: Power against Voltage

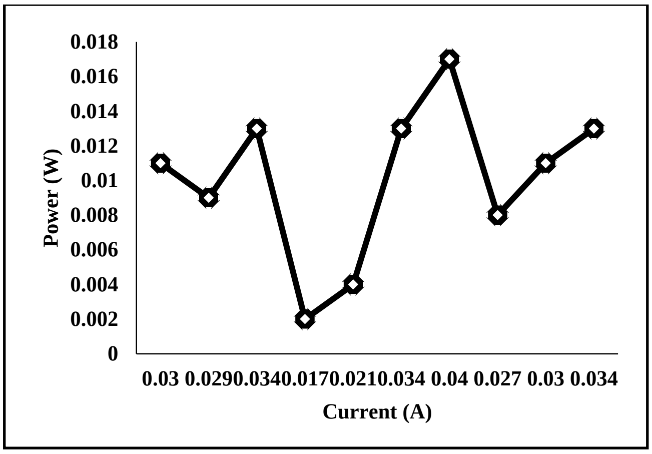

Fig. 7: Power against Current

V.CONCLUSION

The concept of generating electricity using the energy present in the wind is a workable one. Though the result obtained in this project work is not as expected because the wind speed at times in the university environment where the project was done is below the "Cut in" speed required to produce the needed power output. The total current and voltage produced are 0.296 ampere and 3.28 volts respectively. Total power output recorded is 0.095 watt.

Plate 1: Multimeter

Plate 2: Micro Wind Turbine

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