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Experimental comparative study of Electrical power and Electrical efficiency of horizontal axis two and three blade micro wind turbine

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ABSTRACT: In the current socio economic condition of the world power production and its method of production has become the centre of all concerned society and research industry. Producing power without pollution has become the necessity of the present power and research industry.

Wind turbine has an edge over all the power producing methods but it has a dis- advantage of not being operational at low wind speed. In this research work a 60 cm blade micro wind turbine has been developed and tested for its better utility for domestic power production and for lighting purpose in remote area with low wind speed areas. A NACA – 5516 aero foil section was chosen for the development of the rotor blade of the wind turbine. Two set of rotor turbine was developed one with two blade and another with three blade and tested for the various performance aspects i.e. cut in speed, mechanical efficiency, electrical efficiency and rated power to select a better rotor for domestic wind turbine.

During the test it was found that the three blade rotor blade is more sensitive to air and its cut in Air speed 1.7 m/s whereas the cut in speed for the two blade system was found to be 2.5 m/s.

I. INTRODUCTION

Today in 21st century, energy has become an essential part of modern life. The conventional fossil fuel sources are depleting at very high rate and cannot fulfil energy requirement for a very long time. Also fossil fuel based energy sources are costly and pollutes the environment. To overcome these problems a number of work had been done in the field of renewable energy sources and a lot of works are in progress. The renewable energy sources which have been given more importance are solar energy, wind energy and hydro energy. These are the cheapest and cleanest sources of energy.

The wind energy has become a main energy source in field of renewable energy sources. In 2014, 22% of renewable energy was produced by wind farming. In this work, a research on optimization of small wind turbine is to be done for domestic energy generation. Particularly in rural India the domestic turbine or Micro wind turbine can play an important role as it is cheaper than the other sources of power production. Secondly it is pollution free and requires low maintenance. The Micro wind turbine produces low power even at lower wind speed. Therefore minimum requirement of power or lighting can be achieved by this wind turbine. The induction of LED light has given a momentum to this work as even at lower wind speed the lighting task can be achieved efficiently. The object of our project is to develop a wind turbine model with various lift augmentation arrangements to work at low air speed and produce power for domestic use

II. PROBLEM FORMULATION

Though the power production through wind turbine is very economical in the area where wind speed is more than 5 m/s. But in the low wind speed areas the domestic wind turbine may be used to produce small scale electricity to fulfil the personal requirement. The main problem in these areas to operate is to get rated power at lower wind speed. In the present work it is proposed to develop two micro wind turbine one with two blade and other with multi blade. The three blade turbine would generate more torque than two blade turbine and it will rotate at lower wind speed too can be used to produce power at lower wind speed.

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III. EXPERIMENTAL SETUP AND OBSERVATION

Different parts were prepared and collected for the preparation of final proposed wind turbine model. After collecting all these parts, these were assembled to prepare final model. After assembling all of the parts mentioned above the proposed model looks like.

Figure: Complete Experimental Setup

A. List of Components

The main component used in this wind turbine are as follows:

S. No	Name of Components
1	DC Motor
2	Dc Led Bulb
3	Blade
4	Shaft
5	Ball Bearing
6	Hub
7	Stand
8	Anemometer
9	Tachometer
10	Multimeter

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B. Observation

The model was assembled and positioned nose to wind. RPM of rotor was noticed and registered. Here a number of comparative observations of two blade wind turbine and thee blade wind turbine were taken for different wind speed.

Place of experiment	Maharajpur airfield GWALIOR M.P.
Date of experiment	10/05/2016
Tower height	25 meter

Figure: Experimentaion

Experiments were carried at 25 meter tower height at five different wind speed, observation obtained from experiments are attached in annexure 1.

C. Mathematical Calculation

Let,

v_i = $incident\ air\ speed$
v_e = $exit\ air\ speed$
A = rotor swept area
M = mass of the air striking per sec
M = $\rho . A . v_i$
ρ = density of air

K E of the air = $\frac{1}{2}$ M $v_i{}^2$
= $\frac{1}{2}\ \rho . A . v_i . v_i^2$
= $\frac{1}{2}\ \rho . A . v_i^3$

Theoretical power = $\frac{1}{2} . \rho . A . V^3$

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Maximum Theoretical Power Developed By a Wind Turbine:

Theoretical maximum power = $0.59 \, \frac{1}{2} \, \rho \, . A . V_i^3$

Actual power calculation:

Actual power extracted by the rotor = $\frac{1}{2} \, \rho . A . v_a . (v_i^2 - v_e^2)$

Where,

$$v_a = (v_i + v_e)/2$$

Mechanical efficiency = $\frac{Actual \;\; power}{Theoretical \;\; power}$

Mechanical efficiency $= \dfrac{[\; \frac{1}{2} \, \rho . A . v_a . (v_i^2 - v_e^2)]}{[\; \frac{1}{2} \, \rho . A . v_i^3 \;]}$

Electrical efficiency $= \dfrac{\text{Electrical power out put}}{\text{Actual mechanical power}}$

V = Voltage (Volt)

I = Current (mA)

Electrical power = VI

$$\text{Tip speed ratio} = \frac{Rotor \; tip \; speed}{Wind \; speed}$$

Rotor tip speed = r **ω**

Where, r = rotor radius, N= rpm,

ω=2πN / 60

IV. RESULTS

On conducting several observation certain data was obtained, on conducting mathematical calculation Some results were obtained, these are listed below in annexure 2.

A. Variation of load voltage with wind speed for both wind turbine.

Here it is clear that at same wind speed, wind turbine with three blade shows more load voltage than that of with two blade. So it is clear that wind turbine with three blade has more electrical capacity.

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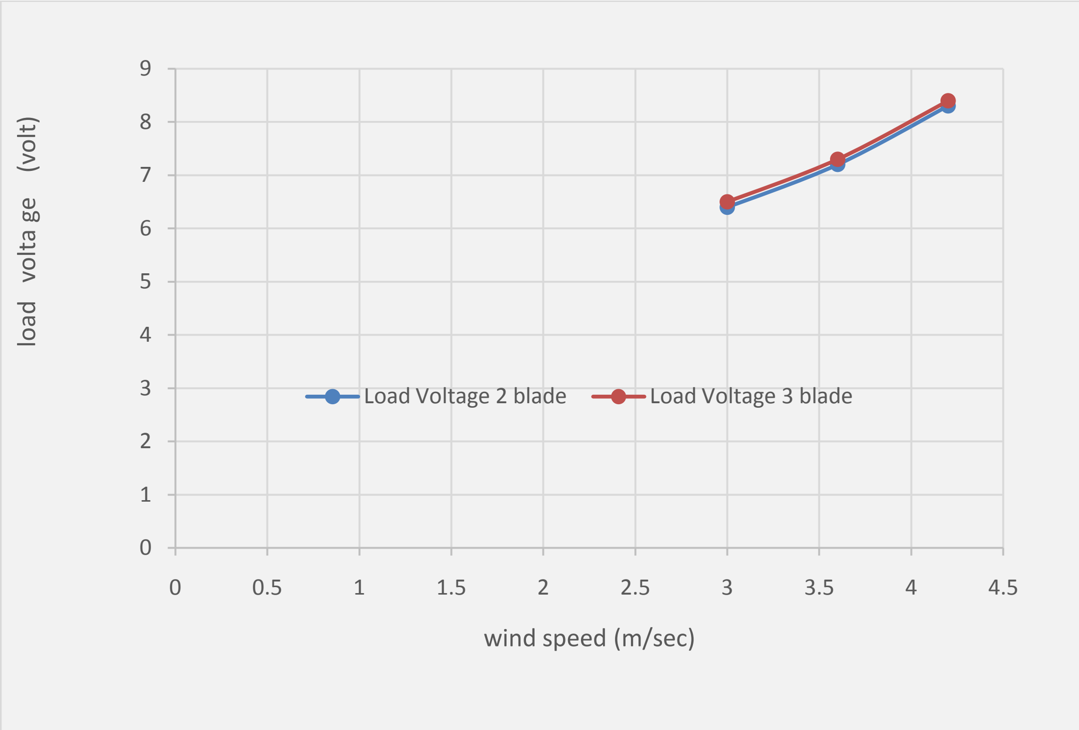
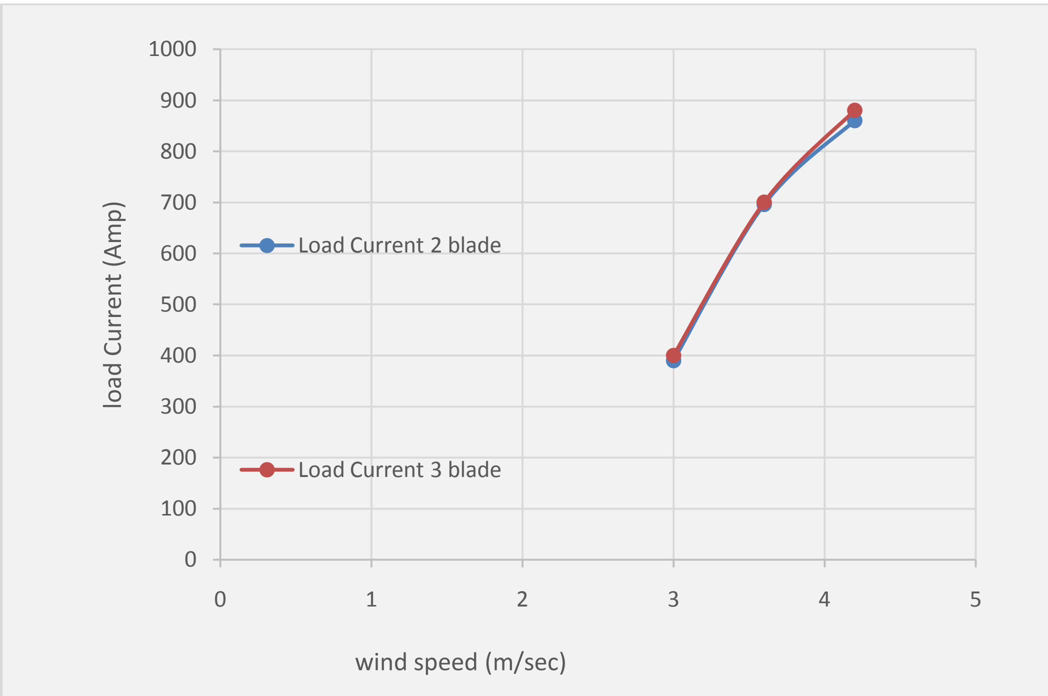


B. Variation of load current with wind speed for both wind turbine.

Here it is clear that at same wind speed, wind turbine with three blade shows more load current than that of with two blade. So it is clear that wind turbine with three blade has more electrical capacity.



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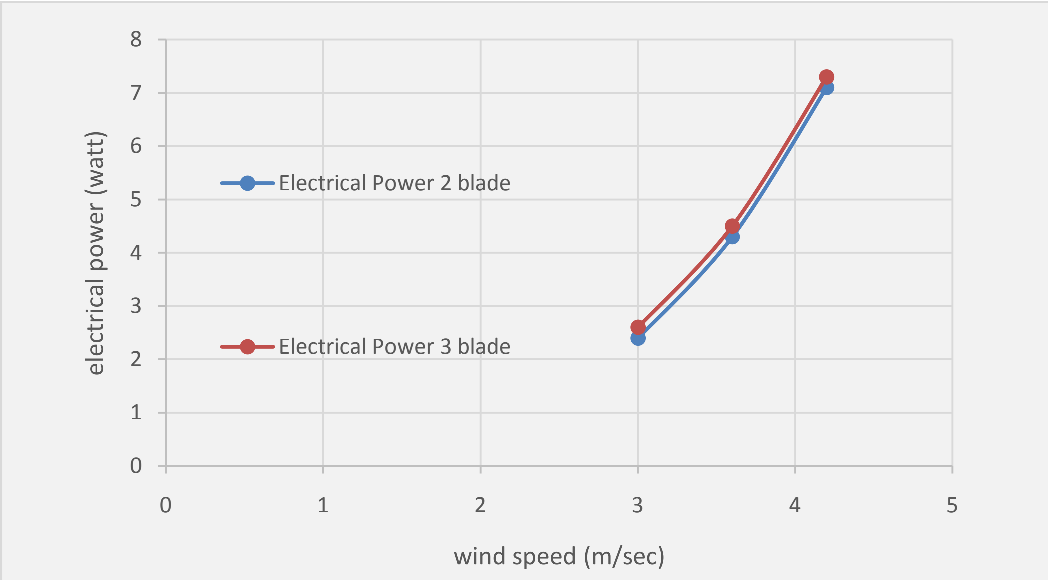
C. Variation of Electrical power with wind speed for both wind turbine.

Here it is clear that at same wind speed, wind turbine with three blade shows more electrical power than that of with two blade. So it is clear that wind turbine with three blade has more electrical capacity.



V. CONCLUSION

The detailed experimental study electrical power and electrical efficiency for both wind turbine has been carried out. Start up speed of both wind turbine also examined. The conclusion obtained are as follows:

1. Wind turbine with three blade is more efficient.
2. Start up speed of two blade wind turbine is 2.5 m/sec while it is 1.7 m/sec for three blade system, hence three blade system is more sensitive.
3. Three blade wind turbine gives more electrical efficiency and more electrical power.

VI. FUTURE SCOPE

The present experimental work has shown many interesting results regarding blade number and design in aspects of blade sensitiveness and efficiency. On the basis of present results some recommendation for future work can be given.

1. Number of blade can be increased for more investigation.
2. A battery based energy storage system can be applied.
3. As it is light weight, compact, small and cheap, an arrangement can be done for household lighting purpose.

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ANNEXURE 1

S. No	Wind Speed (m/sec)	Tower Height (meter)	RPM		Exit Velocity	
			2 Blade	3 Blade	2 Blade	3 Blade
1	3	25	162	170	2.5	2.4
2	3.6	25	168	182	2.9	2.8
3	4.2	25	192	210	3.7	3.6

ANNEXURE 2

A. Results for Two Blade Wind Turbine

S. No	Wind Speed (m/sec)	Exit Velocity (m/sec)	Load Voltage (volt)	Load Current (mA)	Electrical Power (watt)	RPM	Electrical Efficiency (%)
1	3	2.5	6.4	375	2.4	162	30
2	3.6	2.9	7.2	597	4.3	168	31
3	4.2	3.7	8.3	860	7.1	192	32

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B. Results for Three Blade Wind Turbine

S. No	Wind Speed (m/sec)	Exit Velocity (m/sec)	Load Voltage (volt)	Load Current (mA)	Electrical Power (watt)	RPM	Electrical Efficiency (%)
1	3	2.4	6.5	400	2.6	170	31
2	3.6	2.8	7.3	700	4.5	182	32
3	4.2	3.6	8.4	880	7.3	210	33