International Journal of Advances in Engineering Research http://www.ijaer.com

(IJAER) 2015, Vol. No. 10, Issue No. VI, December **e-ISSN: 2231-5152/ p-ISSN: 2454-1796**

DESIGN AND EXPERIMENTAL INVESTIGATION OF MICRO WIND TURBINE

***A Suresh, **S Rajakumar**

**Research Scholar, Department of Mechanical Engineering, Regional Centre of Anna University, Tirunelveli, Tamilnadu-627007, India*
***Asst.Prof. & Head, Mechanical Engineering, Regional Centre of Anna University, Tirunelveli, Tamilnadu-627007, India*

ABSTRACT

The main aim of this paper is to resolve and design a suitable micro wind turbine which could be employed for low speed wind places like urban. The design and fabrication of a locally developed three blade horizontal-axis micro wind turbine was carried out. The blade modelled using CATIA software for NACA 4410 profile. The blade length is 0.3 meters was chosen and the angle of attack was experimentally determined to as 7^0. The turbine blade is fabricated from teak wood because of vast availability, strength, hardness, durability and stiffness. The turbine was installed on the roof of the building. Building's hub height is 10 meters from the ground level. The direct current power output of the test turbine was measured through the digital multi meter. The cut in wind speed i.e., the speed at which the turbine starts to produce power determined at 2 m/s. The test was conducted on different power output at different wind speed. The maximum power obtained as 7.5 watts for 12 m/s, the measured power increase consistently with increase in wind speed and the power curve obtained is compared fairly well with standard power curves

1. INTRODUCTION

Micro wind turbine is generally located in urban areas, where the wind is not strong, due to presence of buildings and other obstacle. To design a good aerodynamic performance of micro wind turbine is to extract maximum power output from low wind speed in these locations [1]. A low Reynolds number airfoil was chosen for designed micro wind turbine to achieve better start up at low wind speed [2].

Small wind turbine performing at low wind speed faces the problem in poor performance due laminar separation bubbles on the blade. To avoid this problem low Reynolds number airfoil was chosen to permit start up at low wind speeds, this increases the starting torque and improves the overall performance of the wind turbine [3].The maximum power co efficient was achieved by variation of sectional lift and drag coefficient. The performance of the wind turbine was improved by the optimum angle of attack on the blade. NACA 4410 is giving more performance than NACA 2415 was proven through the performance analysis and CFD analysis of airfoils [4].

(IJAER) 2015, Vol. No. 10, Issue No. VI, December **e-ISSN: 2231-5152/ p-ISSN: 2454-1796**

The low cost wind turbines with timber blades are good for energy production in standalone operation for developing countries. The results of investigation on the mechanical testing choice of timber for wind turbine testing's of different coating and as well as installation and practical experience with wooden wind turbines done by Nepali. Timbers represent good, strong, reliable and cheap alternative to the traditional composites as low cost and local availability [5].The micro wind turbine has the potential to reduce emission of CO_2 in environment [6].

1.1 MICRO WIND TURBINES VS LARGE WIND TURBINES

Large scale wind turbines are predominantly used for commercial energy production and it is very cost competitive. They are usually connected to a power grid and set up in the locations where wind resource is good enough. Regular turbines are designed for large electricity production hence occupies large area of land. These cannot operate in places where the wind speed is below 10 m/s. Regular wind turbines can only operate at given wind speed between 10 m/s to 25m/s. Micro scale wind turbines (as small as 50 W) are typically used in poor wind sites and autonomous applications that require a high level of reliability. Micro wind turbines are generally off-grid and produce more costly electricity than large and medium scale wind turbines.

Micro wind turbines are often located where the power is consumed and not necessarily where the wind resource is the best. They can be installed in remote places as well as urban areas. Micro wind turbines help to provide energy to the locations where other sources of energy are not available. Thus Micro-scale wind turbines can produce socio-economically valuable energy in developing countries. Micro-scale wind turbines are in fact becoming an increasingly promising way to supply electricity in developing countries. The size of the micro wind turbine can be adapted to the available space and power output required. The design of its simplicity and components are used to make the installation and maintenance easy for anyone. This simplicity allows very low manufacturing cost in turn low price.

Micro wind turbines with very low capacities are best suited for charging the batteries on sailboats and recreational vehicles. Such micro wind turbines have output fewer than 100 W are commercially available and effective for charging batteries with minimum cost and complexity. These micro wind turbines are so small that they can be erected or taken down by a single person in a short time. Micro wind turbines can used to charge automobile batteries and power security lighting systems in remote locations.

1.2 POWER IN WIND TURBINE

Power is extract from wind turbine

$$P = C_p \, 1/2 \; \rho \pi R^2 U^3$$

Where, P =Power in watt, C_p= Power coefficient, ρ = Air density in kg/m^3, R = Radius of the rotor in m,

U = Wind velocity in (m/s).

2. EXPERIMENTAL WORK

2.1 SELECTION OF AIRFOIL

In this work the NACA 4410 profile is chosen for modeling the micro wind turbine blade because of its best lift-drag ratio, good strength properties, good stall characteristics and small center of pressure movement across large speed range, and also its roughness has little effect. NACA 4410 profile is more suitable for micro wind turbine. This profile has more starting torque at low wind speed and it is shown in Figure1.

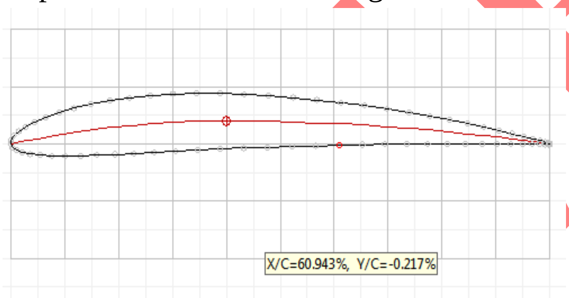

Figure.1 NACA 4410 Series

2.2 SELECTION OF BLADE MATERIAL

Teak wood is used for its high efficiency in Micro wind turbine blades. It was therefore found to be a cheap and effective material for use in wind turbine rotor systems. A teakwood is of the highest natural durability which may be expected to resist both decay and termite attack for at least 25 years. The teakwood exhibits variable grain structure making it easy to shape and sand. It is also known for its strength and flexibility. It has low weight & good strength when compare with other wood. So that blade designs without hollow. Teakwood as a material it has been quite frequently used in turbine blade manufacture.

Table.1 Properties of Teakwood

Properties	Young's modulus	Density	Poisson ratio
	15600 MPA	630 kg/m^3	0.02

2.3 MODELING AND FABRICATION

The geometric model of the wind turbine blade is modeled by using CATIA software and it is shown in Figure 2.

Table. 2 Dimension of blade

Parameters	Dimensions
Blade radius	0.3m
Blade rotor cord length	0.047m
Blade tip cord length	0.017m

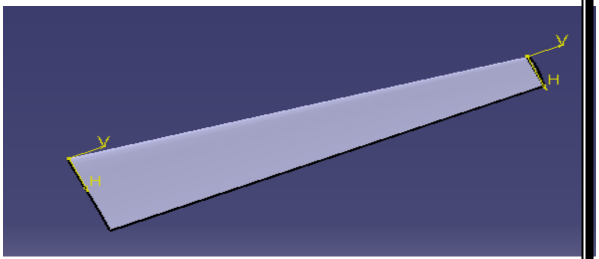

Figure.2 Model of wind turbine blade

Small scale production blades will be fabricated from teakwood. It is more cost effective for high volume production and it is shown in Figure 3.

Figure.3 Fabrication of wind turbine blade

Table.3 Dimension of Hub

Parameters	Dimension
Hub Diameter	0.1m
Hub Thickness	0.005 m
Shaft hole diameter	0.01m

The hub design is simple and inexpensive. The hub consists of one aluminum plate, which are bolted together to hold the blades in place. The hub plate is fixed to the shaft which holds the rotor main assembly. The disassembled view of the rotor hub is shown in Figure 4.A two bolted three blade plate is attached to the hub. It shows an image of the prototype hub completed.

Figure.4 Fabrication of hub

2.4 PERMANENT MAGNET DC GENERATOR AND HUB ASSEMBLY

The permanent magnet generator (PMG) and hub are connected to the shaft through the bearing housing. The bearing housing holds the PMG with aluminum coupling shaft extension in-line with the hub using one bearing on the forward side of the shaft. The PMG shaft coupled with aluminum coupling extension runs through the shaft. The PMG is supported with aluminum coupling, which force the PMG against the bearing housing. When completely assembled, shown in Figure.5. The bearing takes the bending load, and the PMG transfers the thrust load into the shaft.

Figure.5 Assembling of DC Generator and Hub

2.5 NUMBER OF BLADES

The number of blades in wind turbine is an important parameter. It governs the performance, cost, weight, and aesthetics to name a few. For this project, the number of blades was determined by using literature. It has been shown that 3 blades produces relatively good performance for the added cost and complexity of more than 2 blades. A 4-bladed system has slightly better performance; however, the performance does not justify the added cost and complexity of the fourth blade. One can notice that the majority of horizontal wind turbines today are 3-bladed for this reason. The tower is made up of galvanized steel pipe with 6 feet height. The pipe is welded with base plate. The technical specifications of micro wind turbine shown in Table 4.

Table .4 Technical specifications of micro wind turbine

Description	Values
Length of blades	0.3m
Blade profile	NACA4410
Blade material	Teak wood
Number of blades	3
Rated speed	775 rpm
Rated power	10 watts
Charge Controller	12 Volt
Lead acid battery	12 Volt, 7.2 Ah
Blade rotation	Anti clockwise(viewed up wind turbine)
Pitch control	Fixed pitch
Generator	Permanent magnet DC generator
Tower	Free standing lattice or monopole

Figure.6 Assembling of Micro wind turbine

2.6 TOTAL ESTIMATION COST

Table. 5 Total estimation cost micro wind turbine blade

Material	Number of items	Amount in rupees
0.3 m length blade	3	3000

Hub	1	500
Tower	1	1000
Alternator	1	2000
other expense	1	1000
Charge controller	1	1800
Lead Acid Battery	1	350
	Total	9650

3. RESULTS AND DISCUSSION

The mechanical energy is converted into electrical energy in a wind turbine generator. The generator is coupled directly to the input shaft or to the output shaft depending on the rotational speed required by the generator to produce its rated power output.

Table.6 Data collected for performances test of micro wind turbine

Wind speed (m/s)	Generator Speed (RPM)	Voltage (Volts)	Current (Amps)	Power (Watts)
1.5	15.0	1.0	0.01	0.01
2.0	20.0	2.0	0.05	0.10
2.5	30.0	3.0	0.07	0.15
3.0	45.0	4.0	0.08	0.32
3.5	50.0	4.5	0.10	0.45
4.0	70.0	5.0	0.12	0.60
4.5	90.0	6.0	0.14	0.84
5.0	100.0	7.0	0.17	0.77
5.5	130.0	8.5	0.12	1.20
6.0	150.0	9.0	0.15	1.35
6.5	170.0	9.8	0.16	1.80
7.0	180.0	10.0	0.19	1.90
7.5	195.0	11.0	0.20	2.20
8.0	210.0	12.0	0.21	2.52
8.5	290.0	13.0	0.25	3.30
9.0	350.0	15.0	0.26	3.90
9.5	360.0	15.0	0.27	4.07
10.0	390.0	16.0	0.27	4.32
10.5	440.0	17.0	0.28	4.76
11.0	560.0	19.5	0.30	5.85
11.5	610.0	21.0	0.30	6.30
12.0	640.0	22.0	0.30	6.60
12.5	700.0	24.0	0.30	7.20

Micro wind turbine tested to determine the performance of the generator at different rotational speeds. The data collected shows a steady increase of Voltage with increase speed, it raises some concern to the effective function of the generator

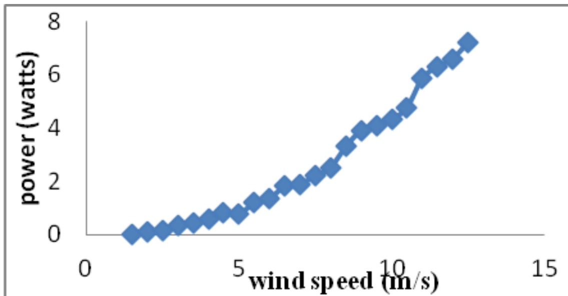

Figure .7 Graph of generator power for various wind speed.

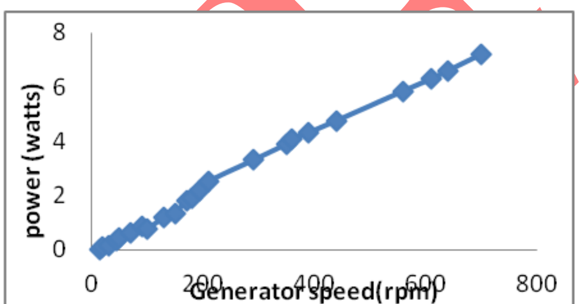

Figure .8 Graph of generator power for various generator speeds.

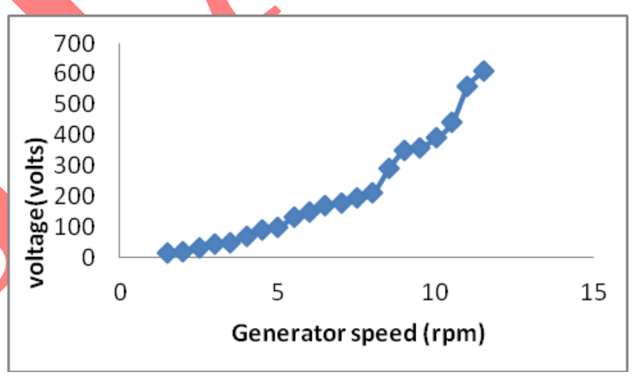

Figure .9 Graph of generator voltage for various generator speeds.

4. CONCLUSION

The Micro wind turbine is fabricated. The NACA 4410 profile blade is designed for high lift force. The test was conducted by Generator power at different wind speed. Data from the field testing of a three blade micro wind turbine is 10 watts. Wind turbine was analyzed at various characteristics of its power generating performance. The maximum power obtained was 7.2 watts for 12.5 m/s. NACA 4410 airfoil was chosen to permit start up at low wind speed 2 m/s and it used to produce more power coefficient by micro wind turbine.

From the test results show that, it is possible to produce a 7.2 watts power using micro wind turbine Generator capacity of 10 watts. It shows that we can produce more power by adopting high capacity wind turbine generator. In this research I have used 24v DC generator to produce a power with maximum capacity of 10 watts. Hence, it is suggest that using the permanent magnet generator can produce more than 100 watts.

REFERENCES

[1] M.Shane and G.Jason .,"Wind Tunnel Analysis of a Counter-Rotating Wind Turbine," Proc. Of ASEE GSW Annual Conference 2009 Texas USA (2009)

Ronit K. Singha, M. Rafiuddin Ahmeda, Mohammad Asid Zullahb, Young-Ho Leeb., " Design of a low Reynolds number airfoil for small horizontal axis wind turbines," Renewable Energy 2012; 42:66-76.

Ronit K. Singh, M. Rafiuddin Ahmed., "Blade design and performance testing of a small wind turbine rotor for low wind speed applications," Renewable Energy 2013; 50:812-819.

S. Rajakumar, D. Ravindran., "Iterative approach for optimising coefficient of power, coefficient of lift and drag of wind turbine rotor," Renewable Energy 2012; 38: 83-93.

Leon Mishnaevsky Jr, Peter Freere, Rakesh Sinha, Parash Acharya , Rakesh Shrestha ,Pushkar Manandhar., "Small wind turbines with timber blades for developing countries: Materials choice, development, installation and experiences," Renewable Energy 2011; 36: 2128-2138.

A.D.Peacock, D.Jenkins,M.Ahadzi,A.Berry,S.Turan., "Micro wind turbines in the UK domestic Sector," Energy and Buildings 2008; 40 :1324–1333.