Construction of Small Scale Wind Turbine for Rural Area Application

Khin Khin Kyaw[1], HlaToe[2], Chu Pyae Moe[3] and Hnit Thit Lwin[4]

Abstract

Horizontal axis wind turbine with three blades was designed and constructed for rural area application. In this research the AC alternator is used for generating output power of 1k W. Blades are made of three elements namely Teak (Tectona grandis), Iron wood (Xyliaxylocarpa) and In-Kanyin. These blades have the same length, the same aero foil shape and the same thickness but they are different density and different weight. Rotor diameter is 2.87 meter. There is no transmission gear in this turbine. Among these blades materials, it was found that the teak wood provides the best starting wind speed of this turbine. The starting wind speed of this turbine is 3ms^{-1} with 150rpm and output voltage is 7V.

Keywords: Horizontal axis, 3 blades, teak, AC alternator.

Introduction

The availability and consumption of energy is an index of prosperity of a country. We need more energy due to population growth, industrialization, mechanization of agriculture production and rising in living standards. Myanmar has many kinds of energy resources, such as fossil fuel, natural gas, hydropower and others. Now, Myanmar is using all sources of energy but the study on use of renewable energy is focused. More energy is expected from renewable energy because the country has large potential in renewable energy production.The wind turbine produce renewable and clean energy which will help reducing global warming and climate change. There are two major types of wind turbine, horizontal axis wind turbine and vertical axis wind turbine. In this paper, The horizontal axis wind turbine with three blades is designed and constructed. For the blades in this research, three different blade materials such as seasonal Teak wood (Tectonagrandis), Iron wood (Xyliaxylocarpa) and Inkanyin will be presented. The block diagram showing the working procedure of wind turbine is shown in figure (1).

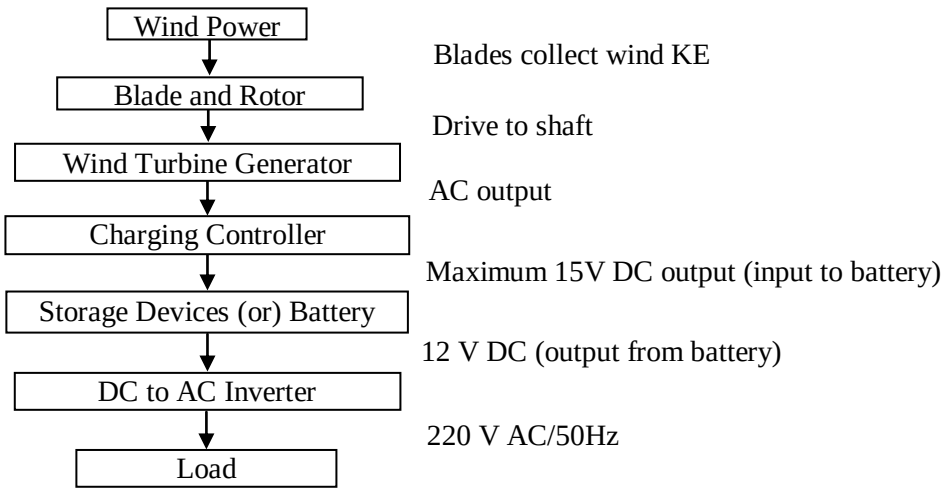

Figure (1). Block diagram showing the working procedure of wind turbine

[1] Associate Professor, Department of Physics, Pyay University
[2] Associate Professor, Department of Physics, Bago University
[3,4]MSc Candidates, Department of Physics, Pyay University

Construction of Wind Turbine

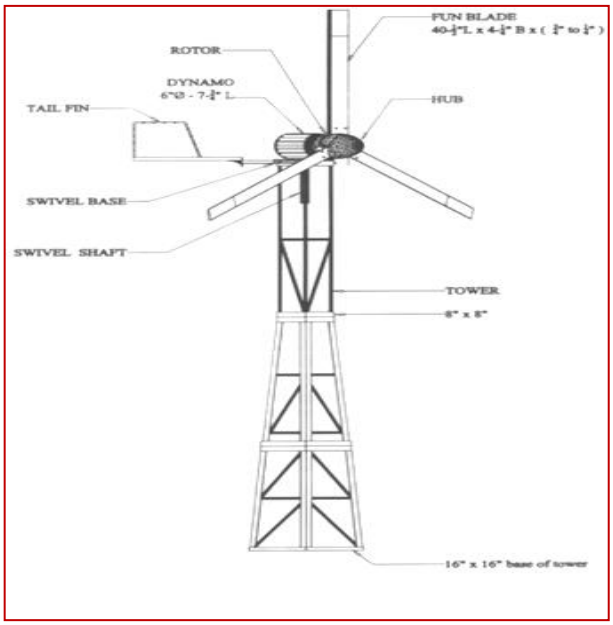

Figure (2). Wind turbine assembly

Horizontal axis wind turbine for electricity generator with three blades is shown in figure (2).It consists of six main parts. These are (1) rotor (2) dynamo (3) swivel base (4) tail unit (5) tower and (6) charging controller. The rotor blades are made of teak wood, Inkanyin and Pyinkadoe. Three blades are same length, same width, same thickness, same pitch angle and different weight and they are in balance. Fiber blades are more expensive than teak wood. Teak wood has more hardness than inkanyin and lighter than pyinkadoe. In Myanmar, Teak wood is better than other wood for all purposes. The shape of blade design is rectangular shape, large root with thin tip form, same length, same aero foil shape and same pitch angle. The axial rod and rotor blades of horizontal wind turbine is designed on aerodynamic principles. The profile is similar to that of aero plane wind. The root of each blade is fixed on the hub. The blade is in a plane perpendicular to the axis of the hub. Hub is one of the important main parts in wind turbine. Metal hub make by the mold for three blades set up to direct shaft generator and fixed to generator shaft. The blades with hub is rotor which is connected to dynamo. Thedynamo with rotor is fixed on the swivel base which is made as the base of the generator and portion of rotor turn into the wind direction. The dynamo is connected with tail vane, tower with axial and battery via charging controller. Tail vane aligned the rotor to change wind direction. The axial rod is composed of two portions, stand to swivel shaft and ball base setup for alloy swivel portion.The turbine is mounted on a tower so it is needed to stand up to wind blowing and weight of turbine. Tower height is 14 feet in two portions in this wind turbine. First portion is based on the ground and tie with three hawser rope. The experimental measurements are shown in figures (3, 4, 5, 6 and 7).The rotation part of wind turbine on specification of blades, TSR and solidity is shown in table (1).

Figure (3). Blade teak wood

Figure (4). Hub for base of wind turbine blade

Figure (5).Tail vane of wind turbine

Figure (6). Axial rod of wind turbine

Figure (7). Construction of Wind Turbine Photos

Table (1). The rotation part of wind turbine on specification of blades, TSR and solidity

Type of Rotor	**Number of Blades**	**Length of Blade(m)**	**Rotor Swept area (m^2)**	**Rotor Surface area (m^2)**	**Solidity**	**Expected TSR**
Airfoil Shape	3	1.219m	4.639m^2	0.373m^2	0.0804	6.6

Results and Discussion

Blades, swivel base, tail unit, tower and charging controller are own design. The blade is carved by hand after cutting the shape roughly on a hand saw. Generator and hub are bought from local market and make the metal casting with mold in Myaung Takar industrial zone, Hmaw Bi Township. Other portions are made in science work shop. Blades and rotor capture the wind force and drive to shaft; shaft rotation and generator produce electricity. The alternator is used for wind turbine generator. It is directed to shaft and DC output is charged to battery via charging controller. Some rural coastal areas have already used small wind generators. The turbine type is up-wind Horizontal Axis Wind Turbine. It includes fixed pitch, tilt-up rotor and generator. The rotor diameter is 2.87 m and rotor blades are made by the teak wood. The rotor speed at 6 m/s is 800 revolutions per minute and output voltage is 12V.Generator is important in all wind turbines. One kilowatt AC alternator is chosen as generator for three blade horizontal axis wind turbine. Maximum output power is 1kW which is 12V and 90A.Tower is not so high but it can absorb wind power in rural area. Tail vane can control to protect of over wind speed of wind turbine. The tail vane is turned to right angle to wind direction, when the wind speed is reached to 25 mph. In this situation the blade is gradually slow down. The tail vane will turn back face to wind blowing direction, when the wind speed decreases less than 23 mph. Experimental data of horizontal axis small scale wind turbine with three blade is shown in table (2). The wind tower photos constructed in Bago University are shown in figure (8). Figure (9) and figure (10) are wind turbine output voltage and output current with wind speed.

Table (2). Experimental data of horizontal axis small scale wind turbine with three blade

Serial	Specification	Measurement result
1.	Rotor diameter	2.87m
2.	Rotor surface area	0.373m
3.	Rotor swept area	4.639m
4.	Blade length	1.219m
5.	Blade surface area	0.124m
6.	Blade material	Teak wood
7.	Dynamo type	Alternator Output AC
8.	Dynamo output power	1kW
9.	Tail unit length	4 feet
10.	Tail vane area	203 inches
11.	Tower type	Mono pole tower (iron pipe)
12.	Tower height	14 feet
13.	Tower control cable	3 steel rope
16.	Swivel ball	Steel ball
17.	Charging controller	Analog
18.	Starting voltage	7V
19.	Cut-in voltage	12V
20.	Cut-out voltage	15V
21.	Rotor RPM	300
22.	Starting wind speed	2 ms^{-1}
23.	Rated wind speed	6ms^{-1}
24.	Maximum wind speed	25mile hr^{-1}

Figure (8). Wind turbine photos

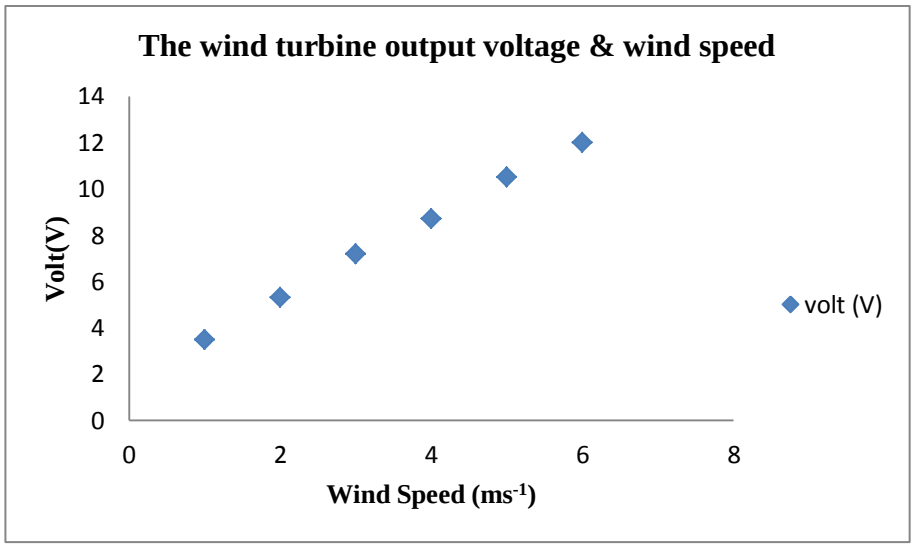

Figure (9). Wind turbine output voltage with wind speed.

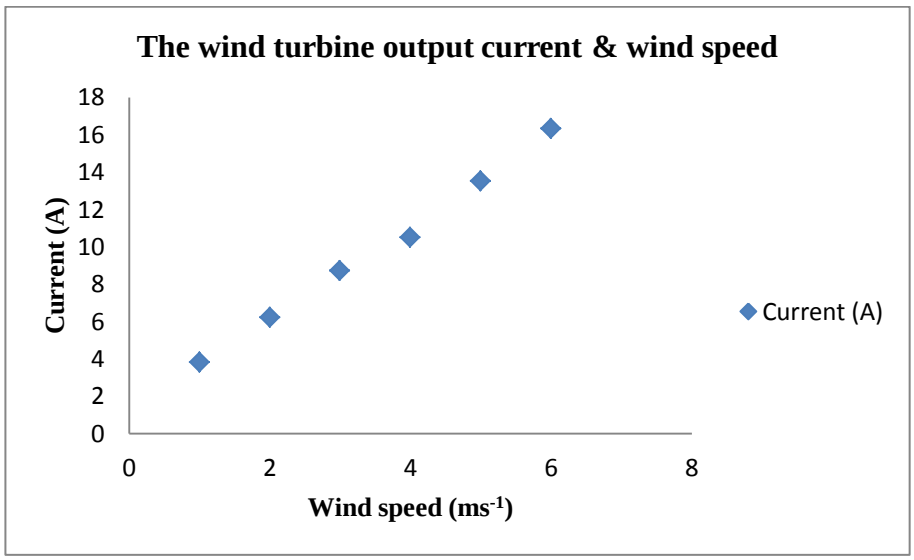

Figure (10). Wind turbine output current with wind speed.

Conclusion

The horizontal axis local make wind turbine with three blades was successfully designed and constructed. This wind turbine can be used for rural area application. People from rural areas who have minimum knowledge of wind energy could manage to use the wind turbine .They can get the minimum daily power requirements such as lighting and watching TV etc. Among these blade materials it was found that the teak wood provides the best starting wind speed of this turbine. In this research work, blades made of teak wood are the best for good service, long lasting and economically low cost. The starting wind speed of this wind turbine is 3 $ms^{-1}$for 7 V and rated wind speed is 6 $ms^{-1}$for 12 V.

Acknowledgements

We would like to thanks Rector Dr Tin Htwe, Hinthada University, for his kind permission to carry out this research paper reading. I also deeply thanks Pro-Rector Dr Mar Lar, Hinthada University, for her valuable support.

References

Craig S. Collier, (1 October 2010). "From Aircraft Wings to Wind Turbine Blades: NASA Software Comes Back to Earth with Green Energy Applications". NASA Tech Briefs. Retrieved 22 August 2011.

Nordex secures first N131/3000in Finland In: Wind power Monthly, Retrieved 22. February 2015.

Weltgrößte Offshore-Turbine errichtet. In: Erneuerbare Energien. Das Magazine Retrieved 22. February 2015.

Zbigniew Lubosny, (2003). Wind Turbine Operation in Electric Power Systems: Advanced Modeling (Power Systems). Berlin: Springer. ISBN 3-540-40340-X.