International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 2, February- 2013

Designing Oftimber Blade Forsmall Wind Turbine

C. Saravanan[1] P. Udhayakumar[2] M. Lydia[3]
[1]PG Scholar/Renewable Energy technologies, [2]PG Scholar/Renewable Energy Technologies
[3]Assistant Professor(SG)/EEE

Karunya University[1,2,3],Coimbatore,India.

Abstract

Renewable energy technologies can provide sources of unlimited, low cost and clean energy to the people in developing countries especially communities in hilly and dry regions. In order to reduce costs of wind turbines and to make this technology more attractive for developing countries, the natural, nearly available materials, mainly wood, can be used to produce parts of the wind turbines instead of or along with conventional composite materials. The paper focuses thepractical implication using low cost, and natural available materials, in particular timber in wind energy technologies.

1. Introduction

In many rural areas, utility scale wind energy developments can be a great way to expand and grow the economy through direct investment and job creation, in addition to significant potential spinoff development activities. Wind energy offers many benefits beyond rural economic development. Wind energy is locally available energy that can extend nonrenewable energy resources, helping to secure our energy needs for future, minimize energy costs, and reduce our dependence on nonrenewable sources of energy.Ingeneral acceptance that the burning of fossil fuels is having a significant influence on the global climate effective mitigation of climate change will require deep reductions in greenhouse gas emissions. The electricity system is viewed as being easier to transfer to low-carbon energy sources than more challenging sectors of the economy such as surface and air transport and domestic heating. Hence the use of cost-effective and reliable low-carbon electricity generation sources, in addition to demand-side measures, is turn to an important objective of energy policy in all countries.Wind power creates no air or water emissions, which increase the health of our environment. Perhaps the greatest benefit of all is the hope that wind energy projects can offer to rural India. In order to reduce the costs of the wind turbines, and to make wind energy more efficient and needs for developing countries, natural, nearby available materials, mainly wood, can be used to fabricate parts of the wind turbines blades using wood instead of conventional, rather expensive composite materials.

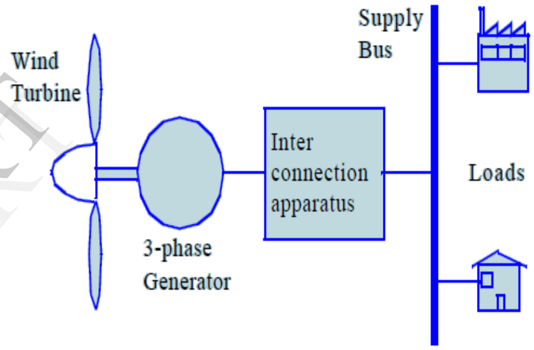

Fig 1 Wind energy standalone conversion system

The major components of a wind energy standalone conversion system include a wind turbine, generation, interconnection apparatus and control system as shown in Fig 1.But design of small wind turbine blade is major issue due to unavailability of proper design which affects the efficiency of a system. To overcome this problem appropriate design have been designed and tested with wind tunnel in this paper.

2. Selection of blade material

The choice of appropriate materials for wind blades requires comprehensive studies, including the analysis of market availability, prices, mechanical testing, fatigue testing, testing of coatings. The mechanical strength, hardness and fatigue behavior are among the most relevant parameters for the estimation of the suitability of the timber material for the use as a wind blade material [1].The list of practically and economically available timber which have a potential to be used for wind turbine blade design. The different timber like lakuri, pine, sal, tuni, okhar and saur taken several test such as young's modulus, breaking strain, average hardness, density, stiffness, elastic properties which can withstand several environmental condition.Lakuri has ability to with stand all environmental condition and suitable for wind turbine blade design.

3. Blade Design Procedure

The process of designing a wind turbine involves the conceptual assembling of a large number of mechanical and electrical components into a machine which can convert the fluctuating power in the wind into a useful form. This process is subject to a number of constraints, but the essential ones implicate the potential economic viability of the design. The cost of energy from a wind turbine is a function of huge factors, but the primary ones arethe cost of the turbine itself and its annual energy efficiency. In addition to the first cost of the turbine, other costs include operation, maintenance, and installation. These will be influenced by theturbine design and must be considered during the design process. The productivity of the turbine is a function both of the turbine's design and the wind resource.

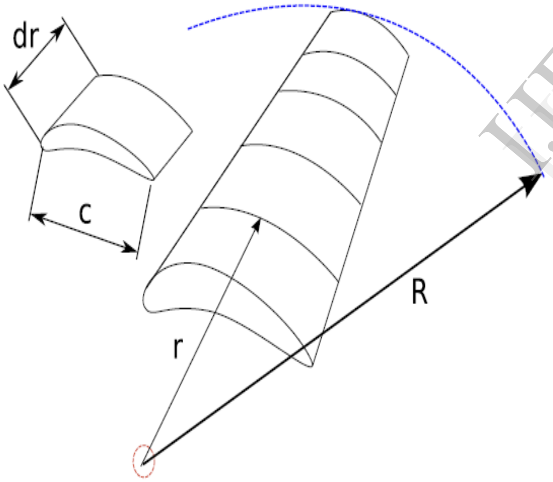

Fig 2Blade element model

For A blade is divided up into *N* elements as shown in Figure 2. Each of the blade elements will experience a slightly different flow as they have a different rotational speed (W_r), a different chord length (*c*) and a different twist angle (g). Dividing up the blade into a sufficient number (usually between ten and twenty) of elements and calculating the flow at each one involves blade element theory. The performance characteristics are determined by numerical integration along the blade span

3.1Length: The blade length determines how much wind power can be caught, rendering to the "swept area" of the rotor disc. All the energy in the wind, only about fractional can realistically be extracted.

3.2Blade Number and Rotational Speed: Typically the rotational speed selected so that the tips are moving at seven to ten times the wind velocity, and there are usually no more than three blades. Maximum speeds and higher numbers of blades mean each blade must be thinner, hence thinner, which makes it stiffer to make them robust enough.At very high wind velocity the rotational speeds of the blades also start to become aerodynamically poor, noisy and prone to erosion. At squat rotational speeds, spin in the wake and tip losses decrease efficiency, while shove loads on the other components increase.

Tip Speed Ratio (λ)	No of blades (B)
1	8-24
2	6-12
3	3-6
4	3-4
>4	1-3

Table 1: Selection ofnumber of blades

Aerodynamic Section: The wind turbine blades build with an aerodynamic property in cross section to create lift to rotate the turbine.

3.3Planform Shape: The planform shape gets narrower to towards the tip to maintain a constant slowing effect across the swept area. This ensures that none of the wind velocity leaves the turbine too slowly (causing turbulence), yet none is leaves to pass through too fast (which would represent wasted energy).

3.4Airfoil Thickness: The thickness improves towards the root to take the physical loads, in specific bending moments. If loads are not important then the section thickness/chord ratio would be about 10-20% along the whole radius of blade. "Flatback" sections may be used near the root to improve efficiency of aerodynamics.

3.5 Blade Twist: The apparent wind angle changes along the blade due to the increase in blade speed with increasing distance outboard. Hence to keep maintain the optimum angle of attack of the blade portion to the wind, it must be keep twisted along its length.

3.6Pitch Control: The wind power varies highly (with the cube of windvelocity), the turbine can be able to generate power in low winds and withstand the loads in much heavy winds. Therefore, above the optimum wind velocity, the blades are typically pitched into the wind (feathering) or away from the wind (active stall) to minimize the generated power and regulate the loads.

Blade length (R) is first calculated by using wind power formulae

$$P = \frac{1}{2}\rho A U^3 (1)$$

Where

P is the power output

ρ is the air density=1.225

A is the swept area

U is the wind velocity=8m/s

To design a blade of 750 W wind turbine

R=0.874 meter

The tip speed ratio(λ) is calculated by

$$\lambda = \frac{R}{V} \qquad (2)$$

ϒ is the rotor rotational speed

v is the wind velocity

R is the radius of blade

λ=5.71

By using equation 2 & 3 can determine the chord of the airfoil

$$c = \frac{8\pi r cos\beta}{3B\lambda_r}(3)$$

β is the relative flow angle onto blades

B is the no of blades

$\lambda_r$is the local tip speed ratio

r is the rotation of axis

$$C=\frac{8*3.14*0.147*cos-80}{3*3*0.9597}$$

C=7.4 cm

4. Selection of airfoil

Several NACA Airfoils tested its lift and drag coefficients using Designfoil software and wind turbine tunnel laboratory setup.

4.1 Subsonic wind tunnel

The subsonic wind tunnel used in aerodynamics laboratory to test the several automobiles application and aerospace application, it can also test wind turbine blades lift and drag coefficient and performance of airfoil.

Fig 3 NACA 4412 airfoil at 0° AOA

Fig 4 NACA 4412 airfoil at 16° AOA

The NACA four digits airfoils 2412, 0015 and 4412 are tested using subsonic wind tunnel in different angle of attack. In Fig 2 and 3 shows the NACA 4412 airfoil at different angles and the smoke visualization has been carried out at different angle of attack.

4.2 Designfoil software

DesignFOIL is an airfoil helpfulness that helps to create, amend, and aerodynamically examine airfoil shapes. It also achieves basic wing layout, CAD export, and crafts CFD preparation files. Although built for specialists, the user-friendly interface is used by many hobbyists as well. The software can test the different airfoils lift and drag coefficient and export to software such as CAD, SOLIDWORKS and CATIA software's.

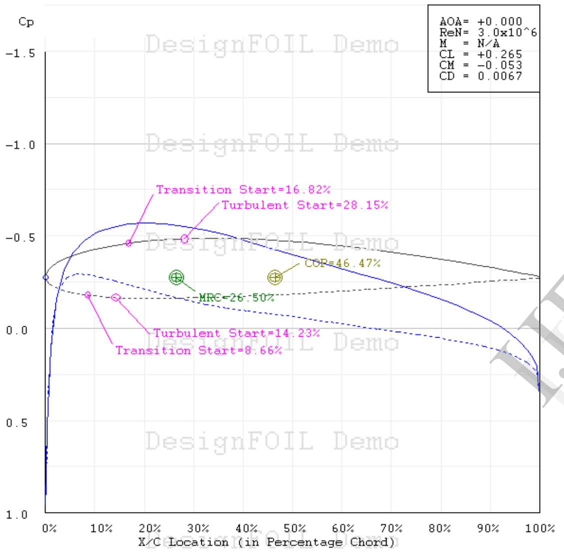

Fig 5 Angle of attack at 0º using Design foil software

Design foil software can identify the different pressure coefficient of a chord of blade at different angle of attack (AOA). The designed airfoils lift coefficient and drag coefficient can be identified without the help of wind tunnel setup.

In **fig 5**the angle of attack at 0° the lift coefficient is +0.265 and drag coefficient is 0.0067 where the lift is high then the drag but it not enough to lift the blade.

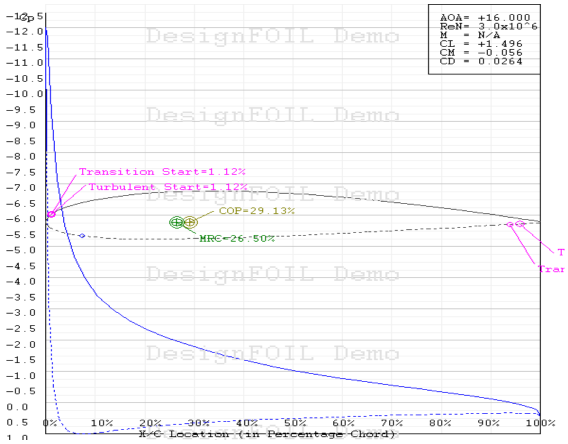

Fig 6 Angle of attack at 16° using design foil software

In **fig 6**the angle of attack at 16°the lift coefficient is +1.496 and drag coefficient -0.056 while compering to the AOA 0° the lift coefficient have been increased and drag coefficient have been decreased so the lifting efficiency of a blade will be increased at AOA 16° the table 2 shows different AOA and their lift coefficient and drag coefficient.

Angle of attack (AOA)	c_l	c_d
0°	+0.265	0.0067
5°	+0.765	0.0012
10°	+0.965	-0.011
16°	+1.496	-0.056

Table 2 Lift and drag coefficient at different AOA using designfoil software

Fig 7 The NACA 4412 airfoil of fabricated blade

In **fig 7** the fabricated NACA 4412 airfoil shape has described geometry and efficiency has increased at 16° AOA by simulating using Designfoil software **fig 7**. The overall structure of the blade using lakuri timber with equation 2 & 3 the fabrication has been carried out.

Fig 8 The Structure of fabricated timber blade

The fabricated blade has been used to carry out several tests in electrical generation system using 3 phase 1 HP PMDC generator using wind tunnel laboratory set up. The tests were carried out in different m/s wind velocity and the rpm and power generation has increased rapidly. The blade was tested in all environmental condition like moisture, heat and water. The blade can withstand all effect and capable to install in all area without any restriction.

5.Conclusion

In the framework of the program of designing and optimal choice of timber materials for low cost wind turbines, it was demonstrated that the whole procedure of the designing (building testing machines, their optimization, testing of different sorts of timber, comparison, testing coatings, blades, development recommendations, etc.) can be realized successfully in a developing country. This is an important pre-condition for the independent, self-reliant development of decentralized wind energy production.The designing of blade structure, selection of airfoil and selection of timber at low cost makes the fabrication perfect and increase the rural area development both in power production for their daily usage as well increase employment jobs in hill station on fabrication of wind turbine blade.

Reference

[1] Leon Mishnaevsky Jr. a,Peter Freereb, RakeshSinhab, ParashAcharyab, RakeshShresthac, PushkarManandhard Small wind turbines with timber blades for developing countries: Materialschoice, development, installation and experiences

[2] Jorge Antonio Villar Ale, Carlos Alexandre dos, Santos Joao Gilberto,AstradaChagasFilho aerodynamic loads and fatigue of small wind turbine blades:standards and testing procedures.

[3] Taehwan Cho*,Cheolwan Kim Wind tunnel test results for a 2/4.5 scale MEXICO rotor.

[4] J. Cotrell,The Mechanical Design, Analysis, and Testing of a Two-Bladed Wind Turbine Hub, National Renewable Energy Laboratory 1617 Cole Boulevard Golden, Colorado.

[5] Erik R. Jogensen, Kaj. K. Borum, Malcolm McGugan, Christian L. Thomsen, Find M. Jensen, Christian P. Debelog Bent F. SørensenRisoFull scale testing of wind turbine blade to failure – flapwise loading.