ANALYSIS OF WIND BLADE

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Abstract—Renewable energy is basically defined as the energy that generate from the natural resources. Energy produced by wind is the type of renewable energy. Wind turbine is the thing which is used to convert the kinetic energy of moving wind into electric power. Wind energy depends upon several factors of wind like Wind power density, Wind speed, Aerodynamics, Turbulence, Forces, Loads, etc. All these parameters are equally applied on turbine blade to produce power. But sometimes the improper amount of these parameters creates inefficiency for turbine and cause damages, failure and some other serious problems in wind turbine blades. In this paper these problems are studies. A paper contains review on different previous journals base on mathematical, experimental, and analytical analysis. We also consider a study of different analysis based on experiment. Work on blade material and new concepts were also reviewed in our work.

Keywords—Wind Turbine Blades, Damage Detection, Experiments, New Concept, Ansys, Materials

I. INTRODUCTION

India is fifth largest country in installed capacity of wind power in the world. Wind energy is the type of most widely used renewable energy now a day. The study here is related to wind turbine which is used for generating energy from wind. Wind turbine is made up of assembly of different parts such as Tower, Shaft, Rotor, Generator, Gears, and Blades etc. But the main part of turbine is its blade. Turbine blades are the key components of wind turbine and needs special care. Blades are designed according to they used and for achieving better efficiency. Some special methods and ideas are used in past for the analysis of blades which are reviewed in this work.

Mathematical models and calculations are used for vibration analysis on Damage detection, Performance evaluation of turbine blades. Experimental methods are used for investigation of actual Failure, Damages and their causes. A new concept used on turbines for applying experiments to get more efficiency. Analysis on software (ANSYS) is a better selection for doing an easy, better and accurate study on different Experiments, Designs, and also for actual blade profiles. Material plays an important role for better work of turbine and need attention. All these parameters are studied in this paper briefly and concluded for future work. The detail study about these topics was conducted in literature survey shown below.

II. LITRETURE REVIEW

The paper gives the review of different work and analysis done on wind turbine blades for increasing overall performance. We explain our study here by dividing the matter into different categories deeply discussed below. A. Analysis of Wind Turbine Blades With the help of Mathematical and

Numerical methods

Yanfeng Wang et.al [1] Damage in turbine blade caused by various reasons and creates serious problems. The paper consist of study of damage detection methods for which a dynamic analysis done on the actual model for calculation of mode shapes. The methods used for blade damage detection based on finite element method (FEM) for modal analysis and mode shape difference curvature (MSDC) for damage detection. A comparison is done with experimental data for design and modification of finite element model. Their numerical solution is able to detect the
location of damage for wind turbine blade. The method also provides a low cost and efficient non-destructive tool for wind turbine blade condition monitoring. A blade of 1.02m of fiber-glass material is used for actual experimental work, and 3D models of blade of 5.5m multi-layer composite for work on software are taken as examples. The frequencies of both the blades at different node with and without damage are studied and compared for further work. It shows the result comparison of first node frequency of blades. Ahmad Sedaghat et.al [2] flow of wind is variable at different regions here in this paper Aerodynamic performance of wind turbine blade at continuously variable speed is studied. A compact BEM (blade element momentum) analysis is use to derived a perfect design for continuously variable speed horizontal axis wind turbine blades. A generalized quadratic equation for calculation of different forces, force coefficient and tip loss are verified in paper. They also calculate values of power coefficient for optimal blade geometry at different tip speed ratio and drag to lift ratio at variable speed. The paper also concluded results for further use like power performance of variable speed wind turbine is higher than the constant speed wind turbine. Three bladed horizontal axis wind turbine with RISO airfoil sections are used and compared for the wind turbine operation under constant and variable speed. Irshadhussain I. Master et.al [3] the paper consists of evaluation and comparison of Aerodynamic performance of wind turbine blade with the help of computational and experimental method. The study in paper considers by the use of NACA 4420 airfoil profile. The lift and drag forces on wind turbine blade and their effect on angle of attack on blade were studied. 00 to 200 is taken an example for calculation. The mathematical calculation and their results of lift to drag ratio. They also carried a CFD analysis at various section of blade. The work in paper concluded that the blade show high Lift/Drag ratio at angle of attack ok 60. Different analysis and their results based on mathematical and experimental analysis shown briefly in the work, with the help of figure and charts. The CFD analysis is used to calculate various pressure and velocity profiles at different angle of attack for better results. A Sharif et.al [4] as we know the manufacturing cost of blade stands for 15 – 20% of total cost of wind turbine, so the wind turbine blade needs special attention. In this paper the production of electrical energy of horizontal axis wind turbine with fixed rotor speed is studied. A mathematical formulation and equations are proposed here for selection of best pitch angle along wind turbine blade that corresponds to the maximum power extraction in site. The experimental data is taken from NREL phase II, and code is developed on blade element moment (BEM) theory for various corrections. They also validate a result of mathematical solution with actual experimental parameters, The work concluded that this mathematics is effective for increase in total power which makes blades economically reasonable.

Experimental Analysis of Wind Turbine Blades on actual models

Yan Li et.al [5] wind turbine placed at very cold places faces a serious problem of icing on turbine blade. In this paper a characteristic of surface icing on blade was studied with the help of actual test.

The study applied on standard profile of NACA 7715 airfoil of wind turbine blade with proper arrangement of apparatus shown in Fig.3. The test conducted in wind tunnel on a blade of 0.22m chord at 0.2m height. The water is sprayed on the blade with nozzle to supply fog at different flow of discharge.

The icing distribution of blade under different wind speed and angle of attack were obtained with the help of camera placed at different position. The result of experiment concluded that the maximum icing rate is 6.6% and maximum icing area ratio is 21.8% at angle of attack ~800. Xiao Chen et.al [6] a wind turbine blade comprises of different weight and forces on it. These continuous loads create failure on blade. So a test conducted on 52.3m glass/epoxy composite wind turbine actual blade model, a static load is applied on blade to simulate extreme load conditions and a flap wise bending load is applied to enumerate failure, The failures were examined with the help of visual inspection and study various conditions. The work also concluded that the test is not applicable for analysis of large blades.
III. EXPERIMENTAL SET-UP

This mini model wind turbine is a small scale turbine that is synonymous with large practical turbines. In this, we have analyzed the blades with more sufficient twist along the chord length to absorb maximum energy from the wind. It enables it to perform equally efficient.

Materials:
- a) PVC pipe
- b) Multimeter
- c) Tachometer
- d) Motor 500 (pitsco)
- e) Electric wire
- f) Battery

Specification:

| I. Blade length | - | 10 inch |
|-----------------|---|---------|
| II. Total height | - | 2 feet  |
| III. Area swept | - | 0.053 m. sq |

In our model, we have used PVC pipe pieces (elbows, T’s) to construct the base, tower and body. The propeller and spinner (used to spin the propeller) is attached to the tower. An anemometer is used to measure wind speed. The turbine can be start by activating the motor with the help of battery and output can be shown in multi-meter.

IV. RESULT

From the graphs, we can see that the value of CL is maximum at 40 degree angle of attack having value of lift 0.75 with correspondence value of lift 0.75.

\[
\text{Lift} = \frac{1}{2}\rho V^2 S C_l = \frac{1}{2} \times 1.225 \times 0.16 \times 0.036 \times 0.75 \\
= 0.2646 \times 10^{-3}
\]
• Drag = $\frac{1}{2} \rho V^2 S C_d = \frac{1}{2} \times 1.225 \times 0.16 \times 0.036 \times 10^{-3}$

$= 0.1764 \text{ N}$

• Power Output $(P) = \rho A V_1 (V_1 + V_2 / 2)$

Where, $V_1$ = Inlet Velocity (m/s)
$V_2$ = Outlet Velocity (m/s)
$\rho$ = Density of Air

• For 40 degree angle of attack, the power output would be,

$P = \rho A V_1 (V_1 + V_2 / 2) = 1.225 \times 0.053 \times 0.4 \times (0.4 + 0.8 / 2)$

$= 0.06272 \text{ Watt}$

| ANGLE OF ATTACK (Degree) | (m/s) | (m/s) | Power (Watt) |
|--------------------------|-------|-------|--------------|
| 10                       | 0.1   | 0.4   | 0.00638      |
| 20                       | 0.2   | 0.6   | 0.01964      |
| 30                       | 0.2   | 0.7   | 0.02156      |
| 40                       | 0.4   | 0.8   | 0.06272      |
| 50                       | 0.1   | 0.5   | 0.00588      |

Graph 1 – Cl vs Angle of Attack
For a small wind turbine, the size of the turbine creates constraints that reduce the no. of parameters required to maximize the efficiency of turbine. It was shown the lift is produced will be larger at 40 degree angle of attack after then it will starts to stall. It is required to have a twist along the chord length to maintain the angle of attack.

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