STRUTURAL ANALYSIS OF WIND TURBINE BLADE: REVIEWS

[1]Santosh Rao ,[2] Dr. Shubhrata Nagpal
(Department of Mechanical engg.)
Email: santoshrao68@yahoo.com

Abstract

Wind turbines blades of propeller type are made according to various blade profiles such as NACA, LS, and LM. There are many factors for selecting a profile. One significant factor is the chord length, which depend on various values throughout the blade. In this work a NACA 4412 profile was created using DESIGN FOIL software to obtain the coordinates of a wind turbine blade in PRO/E. Aerodynamic analysis was done on the created design. Maximum lift to drag ratio was calculated by varying angle of attack of the blade. To find a suitable composite for wind turbine blade, Modal and Static analysis were performed on the modified design using Carbon fiber, E-Glass, S-Glass and Kevlar fiber composites in ANSYS APDL 12.0 software.

Introduction: Nowadays electricity is the major problem in this world especially in Tamil Nadu, India. In the present era of steadily rising fuel costs, wind energy is becoming an increasingly attractive component of future energy systems. The wind potential of India is very high. The wind turbines have been installed and wind energy is being harvested, predominantly in the high wind velocity areas. However, due to the restriction of space, the comparatively lower wind areas are beginning to populate with similar wind turbines. In order to ensure the extraction of maximum wind potential even at lower wind speeds, these turbine blades have to be designed and analyzed to suit the low wind areas. At present India stands fifth in the world of wind power generation. Taking into consideration that a large portion of the Indian land will not be viable for the use of traditional windmills due to low wind speeds, a generator which would produce the energy even at low wind speed is required. Also the transmission losses in India are very high. Hence, to reduce the losses due to transmission the turbine could be placed near the place of consumption. Most of the leading wind turbine manufacturers consider blades as their key components of wind turbine system and have concentrated their efforts on developing their own blade design and increasing the supply through in-house production facility. This paper elaborates the design and development of such a wind turbine blade profile for domestic application by comparison with various profiles. This research work is for generating electricity at low wind speeds and that can be used to power the lighting requirements of a house.

Literature review: Herbert Sutherl and John (2004) effect of mean stress on the damage of wind turbine blades in many studies of composite wind turbine blades, the effects of mean stress on the resolution of injury are either overlooked totally or they are considered ineffectively. An modernized Goodman diagram for the fiberglass resources that are classically used in wind turbine blades has been unconfined lately. This diagram, which is based on the MSU/DOE Fatigue Database, comprises thorough material at thirteen R-values. This diagram is the most complete to date, and it contains any loading conditions that have been unwell embodied in earlier studies. Also, the EFL is a more consistent constraint for comparing fatigue studies because it is not subject to the risky variations noted in typical guesses of service lifetimes, For the statement sets used here, the results illustrate a momentous over estimate of the EFL and an underestimate of the service lifetime when the main stress is not measured. And, the results from the modernized Goodman diagram prove the status of counting material on the changeover between compressive and tensile failure modes in the fatigue account of composites with filament glass.

Hansena et al. (2006) presented the state of the art in wind turbine aerodynamics and aero elasticity, thus the aerodynamic part starts with the simple aerodynamic Blade Element Momentum Method and ends with giving a review of the work done applying CFD on wind turbine rotors. Some methods like vortex and panel are explained in the middle. Also the different approaches to structural modeling of wind turbines are addressed.

Asseff and Mahfuz (2009) developed the Design and Finite Element Analysis of an Ocean Current Turbine Blade, In this study the focus of this work is on the turbine blade design. Much has been learned from the advances in wind turbine blade design, but many differences exist that must be addressed. The medium density in our case is seawater, which is 800 times denser than air, leading to much higher working loads. The ocean is also a very corrosive environment, so materials have to be properly selected. Also, most wind turbine blades are hollow to reduce self weight and cost, but this type of design is not practical for an ocean current turbine.

Pradeep *et al.* (2009) presented the Design and Analysis of Wind Turbine Blade Design System (Aerodynamic), thus The GE 1.5 sle MW wind turbine and NERL NASA Phase VI wind turbine have been used as investigation cases. Particulars of the design system application are described, and the resulting wind turbine geometry and condition are compared to the available results of the GE and NREL wind turbines. A 2D wing investigation code XFLR5, is used for to approximation results from 2D analysis to blade-to-blade assessment and the 3D CFD analysis. This kind of assessment reveals that, from hub to 25% of the span blade to blade effects or the cascade effect has to be calculated, from 25% to 75%, the blade acts as a 2d wing and from 75% to the tip 3D and tip possessions have to be taken into account for design considerations. In addition, the benefits of this approach for wind turbine design and future efforts are discussed.

Vendan *et al.* (2010) developed the analysis of a wind turbine blade profile for tapping wind power in the regions of low wind speed. The aerodynamic profiles of wind turbine blades have crucial influence on aerodynamic efficiency of wind turbine. In this paper NACA 63-415 airfoil profile is considered for analysis of wind turbine blade. NACA 63-415 airfoil profile is shaped by using the corresponding file generated in Java Foil.

Naishadh Vasjaliya and Sathya Gangadha-Ran (2011) presented Aero-Structural Design Optimization of Composite Wind Turbine Blade, The objective behind this research is to develop a Fluid-Structural Interface (FSI) system for SERI-8 composite blade to get benefit of aerodynamic efficiency and structural toughness while tumbling blade mass and cost. In the earlier research, a MDO procedure of a composite wind turbine blade has been pioneered as effective process to develop structurally optimized blade design.

Fangfang Song *et al.* (2011) presented Optimization Design, Modeling and Dynamic Analysis for Composite Wind Turbine Blade, The performance analysis of wind turbine blades are important parts of the design and also he has been solved this paper using MATLAB tools in Wilson method. FEM method is analysis for the composite material modeling method of combining of solid work with ANSYS.

Jang-Oh Mo and Young-Ho Lee (2012) have developed cfd investigation on the aerodynamic characteristics of a small-sized wind turbine of neural phase VI operates with a stall-regulated method, where Five different inflow velocities, in the range Vin = 7.0-25.1 m/s, are used for the rotor blade calculations. The considered power coefficient is in relation to 0.35 at a TSR of 5.41, equivalent to 7 m/s, and showed significantly fine concord with the new capacity within 0.08%. Therefore, root design approaches were considered the appropriate selection of the angle of attack and the thickness are very important in order to generate the stall on the blade root.

Kevin Cox and Andreas Echtermeyer (2012) presented Structural design and analysis of 10 MW wind turbine blade, in this project 70 m long blade used in high wind speed location. Such that Glass and carbon fiber used in weight reduction, FEA method is the problem solved. In concluding the Maximum and minimum strain and deflection is identified. For blade tip.

Zafar Hameeda and Jørn Vatn (2012) developed the important challenges for 10 MW reference wind turbine from rams perspective, RAMS Mean Reliability, availability, maintainability And Safety. Here rams analysis has become an active area of research to measure the efficiency of any operational system for evaluating its performance as per its designed features. Thus, finally the areas and problems are easily identified and the optimized design tends to produce better efficiency and effective working condition of the machine.

Jihoon Jeong *et al.* (2012) design optimization of a wind turbine blade to reduce the changing unsteady aerodynamic load in turbulent wind Design optimization of the wind turbine of a NREL 1.5-MW HAWT blade was deliberate to reduce the fluctuation of the bending moment of the blade in turbulent wind. In order to examine the unsteady aerodynamic weight of a wind turbine, FAST code was used as the examination code. To study turbulent wind as the wind input model in FAST, TurbSim was used as a turbulent wind simulant. Accordingly, the result of the design optimization is comparedwith the baseline for variation in the out of plane bending moment at the blade root and for the required generated power. In addition, the section services for the radial station around the out of plane and in plane were investigated to deliberate the load appearances of the optimized blade. Next, the local angles of occurrence of the optimized blade in each airfoil section are associated to that of the baseline blade. Finally, the robustness of the optimized blade was authorized according to various wind speeds with off design examination.

Maryam Refan and Horia Hangan (2012) Aerodynamic Presentation of a Small Horizontal Axis Wind Turbine The aerodynamic presentation three-bladed, minute Horizontal Axis Wind Turbine (HAWT) rotor of 2.2 m in diameter was examined experimentally and theoretically in order to measure the applicability of the Blade Element Method (BEM) theory for screening the rotor presentation for the case of small HAWTs. The wind turbine has been experienced in the little and high speed pieces of the Boundary Layer Wind Tunnel 2 (BLWT2) at the University of Western Ontario (UWO) in order to regulate the power curve over a wide range of wind speeds. Furthermore, the rationality of wind tunnel testing and new systems, counting full scale HAWT wind tunnel tests and impasse improvements were lectured. The overall choice of the present work is, therefore, twofold: (i) evaluating the probability of wind tunnel testing for small HAWT to determine resolute power arcs even for high solid blockage ratios, and (ii) appraising the possible limitations of the BEM theory to forecast small HAWT performance.

Bai *et al.* (2013) designed 10 KW Horizontal-Axis Wind Turbine (HAWT) blade and aerodynamics investigation using numerical simulation, in this system the horizontal axis wind turbine blade with 10000 watt power output has been designed. The BEM theory is very successful in HAWT blade design. Wind speed 10 m/s tip speed ratio 6 and angle design 6 deg, Turbine blade performed by the CFD numerical simulation. The simulation result compared BEM theory wind speed of 10 m/s. Finally author concludes CFD is good method of aerodynamic.

Waleed Ahmed (2013) modelling of Wind Turbine: Relative Study this paper discovers the modelling of gear train of the wind turbine and extricates the difference in the approaches usually used to found the mathematical model which is later has a significant influence on the design, characteristic and presentation of the modelled system. Mainly two commonly used advanced for the gear train systems are analyzed and deliberated. The main well known mechanisms are examined in term of the most proposed expectations to contract with the damping, shaft stiffness and inactivity effect of the gear. In general, the concept of using the wind energy to find the electricity power can be characterized by the following diagram. wind turbine gear box consists of two main shafts, the low speed shaft which is fundamentally connected with the wind turbine blades, and the second one is high speed shaft linked directly to the manufacturer.

Khelladi *et al*. (2014) analysis and learning of the aerodynamic turbulent flow arounda blade of wind turbine the flow around a wind turbine is a set of forces practical by the wind on the blades distinct by the most momentous parameters from a dimensional analysis describing the power of wind turbine. This later is criss spanned by changes of turbulent strength unlike the Reynolds number essential parameter and not unique for the change in turbulent flow. Thus the presentation of the wind turbine depends on the specific speed that allows to get the most power constant by managerial the speed. The option of regulating power of the current high-speed wind turbine by changing the blade angle and or speed of rotation of the blades, unlike the older generation in active stall control of the blade, will lead to a study of the stress of the blade by the occurrence wind aerodynamic forces and therefore of the flow around a wind turbine and the identification of the most see through parameters for dimensional study of the power.

In above literature wind turbine there was a strong coupling between aerodynamic loads, the time dependent structural behavior of construction. Through a clear understanding an aerodynamic characteristics of the small-sized wind turbine, it is so expected that useful aerodynamic data will be made available to designers as guidance in designing wind turbine blades in the development phase of small-sized wind turbine systems in the future. Design of wind turbine blades to obtain a structurally optimized blade design with optimal blade thickness distribution and maximum power output without compromising its aerodynamic performance.

Conclusion: this paper provides an overview of the using current state and futures challenge in the wind turbine blade in fatigue life optimization, blade performance, blade materials, fatigue performance, blade design. The design of the wind turbine blades must be structurally optimized with optimal blade thickness distribution and maximum power output. The wind turbine blades are manufactured using composites materials with carbon fiber reinforcements. These materials are having less cost, high strength and stiffness.

Reference

[1] Herbert J Sutherl and John F "Effect of Mean Stress on the Damage of Wind Turbine Blades", Vol. 126,, **(2004)**. pp. 1041-1049.

[2] Hansena M O L, Sorensen J N, Voutsinas S, Sorensen N and Aa Madsen H "The State of the Art in Wind Turbine Aerodynamics and Aero Elasticity", *Progress in Aerospace Science*, Vol. 42, , **(2006)**. pp. 285-330.

[3] Asseff N S and Mahfuz H) "Design and Finite Element Analysis of an Ocean Current Turbine Blade", Vol. 38, , **(2008)**. pp. 1-6.

[4]. Pradeep A V, Kona Ram Prasad and Victor Babu T "Design and Analysis of Wind Turbine Blade Design System", Vol. 2, , **(2009)**.pp. 1038-1046.

[5]. Vendan S P, Aravind Lovelin S, Manibharathi M and Rajkumar C "Analysis of a Wind Turbine Blade Profile for Tapping Wind Power at the Regions of Low Wind Speed", *Intenal Journal of Mechanical Engineering*, Vol. 2, , **(2010)**. pp. 1-10.

.[6] Fangfang Songa, Yihua Nia and Zhiqiang Tanb "Modeling and Dynamic Analysis for Composite Wind Turbine Blade", Vol. 16, , **(2011)**. pp. 369-375.

[7]. Naishadh G Vasjaliya and Sathya N Gangadharan "Aero-Structural Design Optimization of Composite Wind Turbine Blade", , **(2011)**. pp. 1-17.

[8] Jang-Oh Mo and Young-Ho Lee "CFD Investigation on the Aerodynamic Characteristics of a Small-Sized Wind Turbine of Nrel Phase Vi Operating with a Stall-Regulated Method", *Journal of Mechanical Science and Technology*, Vol. 26, **(2012)**. pp. 81

[9] Jihoon Jeong, Kyunghyun Park, Sangook Jun, Kisun Song and Dong-Ho Lee "Design Optimization of A Wind Turbine Blade to Reduce the Fluctuating Unsteady Aerodynamic Load in Turbulent Wind", Vol. 26, **(2012)**., pp. 827-838.

[1]0 Kevin Cox and Andreas Echtermeyer "*Structural Design and Analysis of a 10 mw Wind Turbine Blade*, January 19-20. , **(2012)**.

[1]1 Maryam Refan and Horia Hangan "Aerodynamic Performance of A Small Horizontal Axis Wind Turbine", Vol. 134, , **(2012)**. May.

[12] Zafar Hameeda and Jørn Vatn (2012), "Important Challenges for 10 Mw Reference Wind Turbine from Rams Perspective", January 19-20.

[13] Waleed K Ahmed " *Mechanical Modelling of Wind Turbine: Comparative Study*, Vol. 3, **(2013)**., No. 1.

[14] . Bai C J, Hsiao F B, Li M H, Huang G Y and Chen Y J, "Design of 10 Kw Horizontal-Axis Wind Turbine (HAWT) Blade and Aerodynamic Investigation Using Numerical Simulation", Vol. 67, , **(2013)**. pp. 279-287.

[15]. Khelladi S, Bibi Triki N E, Nakoul Z and Bessenouci M Z "Analysis and Study of the Aerodynamic Turbulent Flow Around A Blade of Wind Turbine", Vol. 55, , **(2014)** pp. 307-316.