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Parametric Modeling & Study Of Structural Characterics Of Wind Turbine Blade

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Abstract

The structural aspects of a long blade in a an up wind, horizontal-axis wind turbine were hybrid composite structure using glass and carbon fiber plies was created yielding a light-weight design with a low tip deflection. The results confirmed the design to have acceptable performance with regard to tip deflection, maximum and minimum strains, and a critical load. Detailed descriptions of the structural components and ply layups are presented along with resulting maximum and minimum strains and deflections. In addition, optimization techniques were introduced to provide insight for future studies with the blade a detailed review of current state of art for wind turbine blade design is presented. A design different airfoil cross section ('I','C', Double 'C').and Structural analysis, FatigueCharacterics of Wind Turbine Blade. key words : parametric design, structural analysis

1.Introduction

Wind turbines have begun moving from land installations to offshore locations in an effort to harness the faster and steadier winds that exist there. When moving turbines offshore, the trend is to increase the rotor diameter so that more of this steady wind can be captured, ultimately decreasing the cost of energy [1]. Wind energy has become one of the most important renewable energy sources. In a horizontal axis wind power system, turbine blades are used to convert wind energy to electricity. In general, turbine blades are required to be light and have small mass moment of inertia so that they can start to rotate at low wind speed[2]. structures, the optimal lay-up schema can be determined, and the verified analysis of stiffness and strength can be performed under extreme load conditions[3]. An aerodynamically efficient blade is the prime necessity to extract maximum power from a wind turbine. With the increasing size of the wind turbine blade, the blades are now basically made of composite materials. Composite materials satisfy complex design Constraints such as lower weight and proper stiffness, whereas providing good resistance to the static and aerodynamic loading. In the research on the structure of wind turbine blade, there are two main aspects that were focused on. The first is about the study of structural testing and simulation of the wind turbine blade. For instance, Shokrieh simulated fatigue failure in a full composite wind turbine [6].

2. Blade Design:

The structural design process of the wind turbine blade is constrained mainly by the aerodynamic outer surface of the blade and required stiffness criteria. Because the aerodynamics of the blade were not the focus of this study, The aerodynamic shell of this 40 meter blade was designed using blade element momentum theory andutilized the same airfoil families as those in the NREL 1 MW turbine. The blade shape and length as well as information on the design parameters provided a starting point for developing the structural definition. There are typically three members contributing to the stiffness of the blade so that it is able to resist the various loads. In addition to capturing the wind and converting it into torque, the airfoil shell provides the blade with stiffness to resist torsional and edgewise bending loads. Flap wise bending is the most significant load subjected to the blade and is resisted by utilizing a thick section of stiff composite material on the upwind and downwind sides of the airfoil. These stiffened sections are termed spar flanges and are connected by shear webs. The shear webs provide some torsional and edgewise bending stiffness but mainly contribute to shear stiffness.

3. Material selection

Blades currently used in industry for large turbines are composed of fiber composite materials so that a stiff, lightweight design with a high fatigue life is achieved. The fibers for wind turbine blades are typically oriented to 0^o, $+45^o$, and -45^o orientations, with 0o being parallel to the blade span direction, or pitching axis. Plies with 0o fibers are used for resisting bending while plies with $+45^o$ fibers are implemented for torsional stiffness and buckling resistance. Other combinations of fiber directions can be used, but the 0/+45 ply layup is the most practical from a manufacturing point of view. Implementing a core material into a composite layup is a light-weight method to increase buckling resistance. The core material in Table 1 was chosen for its low weight and high shear modulus which is important for sandwich structures subjected to bending. This material was applied in all regions except for the spar flanges and the airfoil shell regions overlaying the flanges. The lining isa thin composite layer with short, randomly oriented fibers used as a protective layer for the glass, carbon, and core ply layups. Finally, the gel coat was used as the outermost layer on the airfoil skin to create a smooth, aerodynamic surface for the blade.

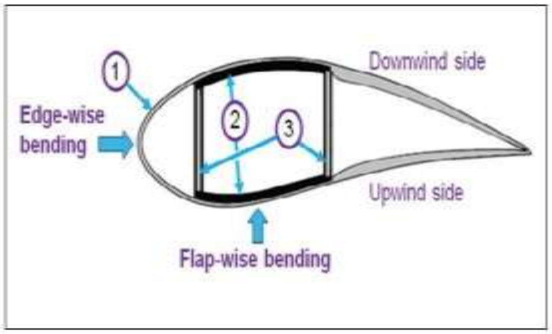


Fig.1. CROSS SECTION OF A BLADE WITH REFERENCES TO THE AIRFOIL 1.SHELL, 2.SPAR FLANGES, & 3.SHEAR WEBS

4. Structural analysis:

Static numerical simulation of wind turbine blade is to analyze and study its stress and strain of different lay-up structures. And then to determine the optimal lay-up schema aimed the maximum structure strength and stiffness as final goal. To finite element analysis of composite lay- up structure, different laminations adopt different element types and attributes. Because of the random orthogonal aeolotropism of GRP mechanical performance, material performance relates to its main arbor orientation, lay-up number and lay-up thickness. Special layer elements is used to simulate composite and composite parameters of the blade, such as lay-up angle, lay-up number and lay-up thickness can be set. The boundary condition of finite model is to fix the blade root fully, to act wind pressure on the blade out-surface, and to act weight and centrifugal loads on calculating model.

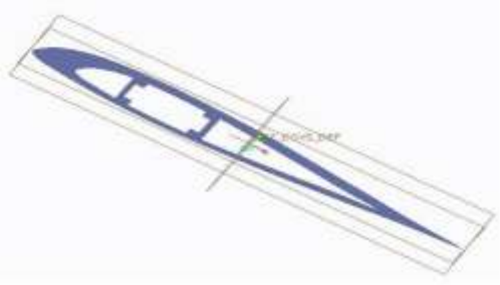
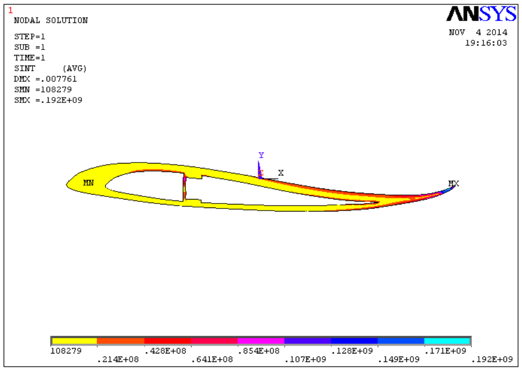


Fig 4 Double ‘C’ section

6. Structural analysis

Fig 5 ‘I’ section stress intensity

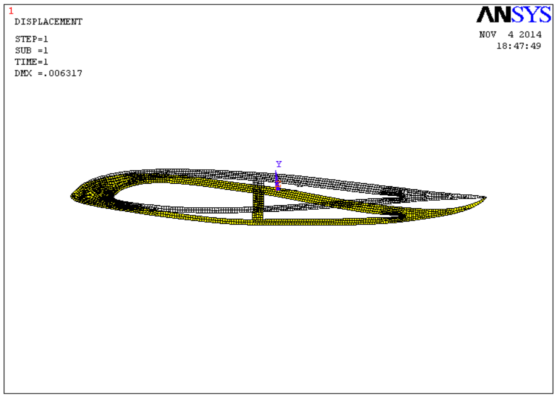


```
1
NODAL SOLUTION

STEP=1
SUB =1
TIME=1
SINT      (AVG)
DMX =.007761
SMN =108279
SMX =.192E+09
```

Fig 6 ‘C’ section stress intensity

Fig 7 Double ‘C’section stress intensity



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1
DISPLACEMENT

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TIME=1
DMX =.006317
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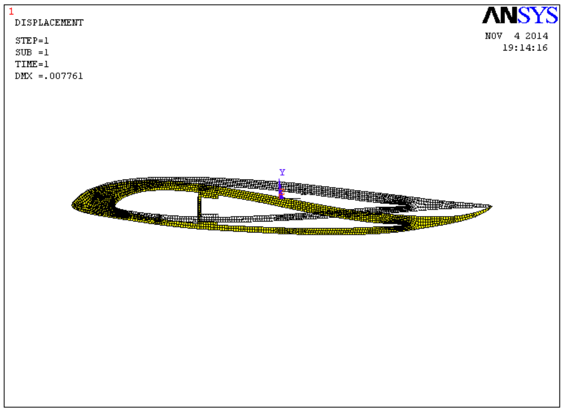
Fig 8. ‘I’ section deform shape



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1
DISPLACEMENT

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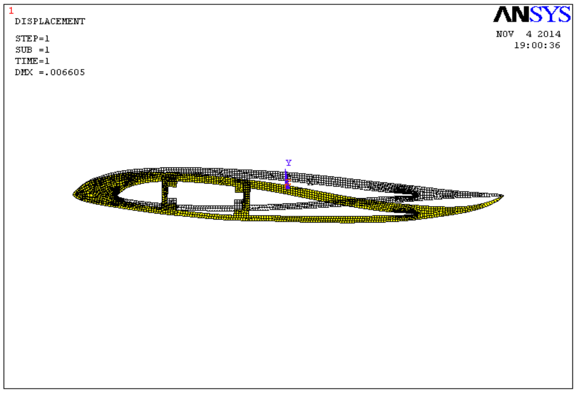
SUB =1
TIME=1
DMX =.007761
```

Fig 9 ‘C’ section deform shape



```
1
DISPLACEMENT

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SUB =1
TIME=1
DMX =.006605
```

Fig 10.Double ‘C’ section deform shape

Table 2.Results

AIRFOIL TYPES	DEFORM SHAPE (m)	STRESS (N/mm2)	STRAIN (No Units)	'Y' DISPLACEMENT (m)	STRUCTURAL 'Y' FORCE (N)
'C' SECTION	0.007761	.192E9	0.006784	.137E-4	12481
'I' SECTION	0.06317	.190E9	0.00673	.140E-4	11049
DOUBLE 'C' SECTION	0.006605	.191E9	0.006752	.166E-4	9790

7. Result and discussion

The proposed structural analysis method is first used to determine the load- displacement curve of wind blade. Such difference may be due to the variations in material properties, uncertainty in testing, and nonlinear effects neglected in the finite element model. Both the theoretical and experimental failure locations, however, are at the blade root. . The Bernoulli's equation is used to find wind pressure for given wind speed. The verified analysis of stiffness and strength of the optimal lay-up schema is performed under extreme load conditions. A comprehensive optimization process for a 1MW wind turbine rotor is developed for simultaneous consideration of airfoil geometry, chord distribution, twist distribution, and desired bend-twist coupling. As expected, successive decreases in COE were observed with an increasing number of design variables. Future work is needed in order to examine the effect of increasing the number of design variables. Additional constraints blade roughness sensitivity, airfoil shape compatibility. The procedure proposed not only allows thickness variation, but also permits the spar cap location variation over the structure. Then the strain of the blade is analyzed, and the location of the main bending strain is pointed out. The next step could be the multi-objective optimization of the wind turbine blade. A different airfoil cross sections are analysis for stress, strain, displacements are calculated, list out the above tables.

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