Design And Analysis of Wind Turbine Blade

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Abstract- In this paper wind turbine blade prototype is analyzed using finite element analysis (ANSYS) for various loading conditions at survival speed and cut of speed. Wind turbine blade undergoes variable static and dynamic during its actual life cycle. Modern wind turbine blades are designed to withstand various dynamic loading conditions. A wind turbine blade undergoes failure in combination of flap wise and edge wise. For optimum design of wind turbine blades, there should be proper selection of materials for turbine blades. Wind turbine blades are manufactured by using composite materials such as epoxy resin, and various other carbon fiber reinforced plastics.

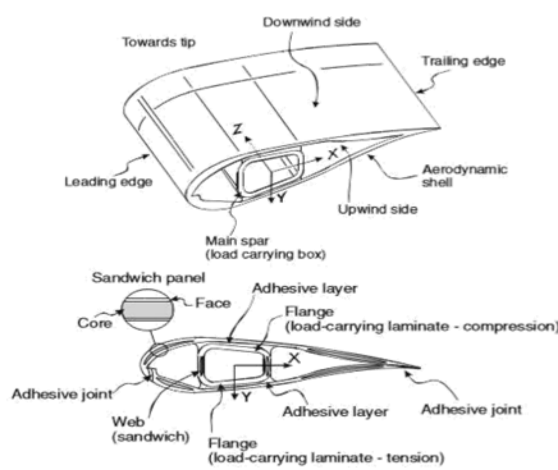
I. INTRODUCTION

The structural design of wind turbine blades for horizontal axis wind turbine is a complicated process that requires the keen knowledge of materials, modelling and testing methods. A wind turbine blade must be designed against undesired aero-elastic phenomena and failures for a great variety of aerodynamic load cases and environmental conditions. Thus, the design process involves a number of different areas, such as knowledge of the external loads originating from wind and gravity and knowledge of the performance, the strength and the endurance of the full structure and of the basic materials used. The goal of the design process is to ensure that the wind turbine blade will function safely for its design life. The design lifetime of modern wind turbines is normally for 20 years and number of rotations is of the order 108 to 109, which is approximately two orders of magnitude higher than the load cycles experienced by composite materials used in other highly loaded structural applications such as helicopter blades.

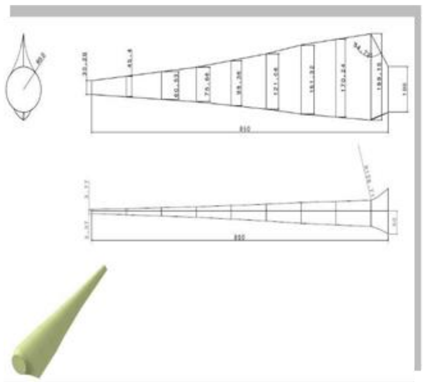
The main trends in the development of wind turbine blades are towards longer and optimized blades; this is particularly the case for offshore wind turbines. The weight of a large wind turbine blade also increases the loads on the rotor input shaft and bearings as well as the wind turbine tower and mechanisms used to control yaw and pitch of the blades. Weight savings is therefore of great importance, and significant efforts are devoted by wind turbine companies in the selection of materials. To ensure that the blades can meet the required design life, the materials must have high stiffness, be fatigue resistant, and be damage tolerant. The orientation of the shaft and rotational axis determines the first classification of the wind turbine. A turbine with a shaft mounted horizontally parallel to the ground is known as a horizontal axis wind turbine or (HAWT). A vertical axis wind turbine (VAWT) has its shaft normal to the ground as shown in figure below.

II. GEOMETRIC MODELS

1. Structure of Wind Turbine Blade

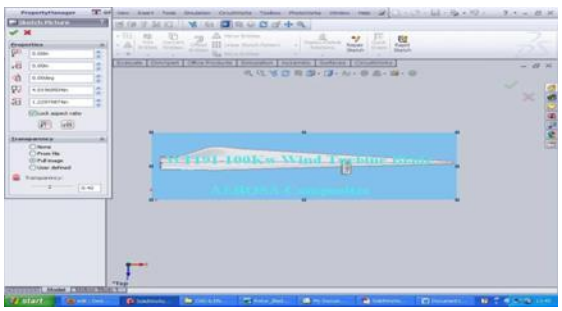


2. 2D Model of Wind Turbine Blade

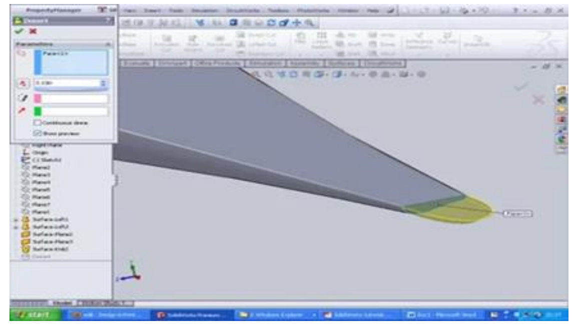


A. 3D Model of Wind Turbine Blade.

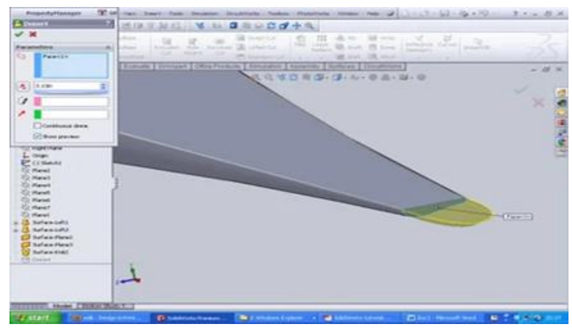
1. 3D wind Turbine Blade



2. Solid Model



3. Final 3D wind turbine blade



- ANALYSIS OF WIND TURBINE BLADE

The wagon wheel and track in solid works model is converted to iges to import in the annoys software After importing the geometry two different speeds are assigned. They are Survival speed Cut out speed Pressure.

A. Analysis of wind turbine blade,
Survival speed=59.5m/s,p=2200Mpa.

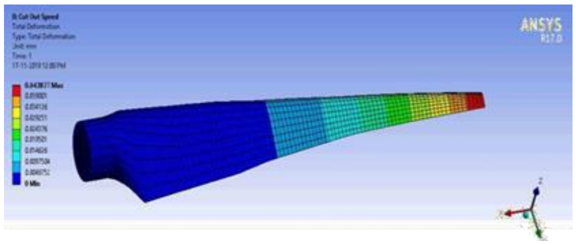
1. Wind speed to pressure conversion chart

WINDSPEED TO PRESSURE CONVERSION CHART

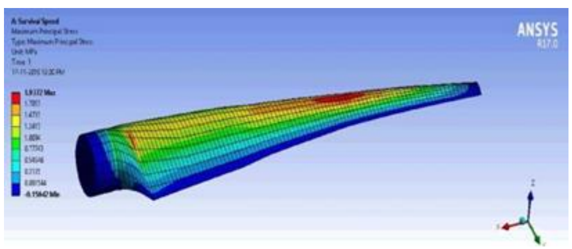
Metres/Second m/s	Kilometres/Hour km/h	Miles/Hour mph	Pascals Pa
6.38	22.97	14.28	25
9.03	32.50	20.19	50
11.06	39.80	24.73	75
12.77	45.96	28.56	100
15.63	56.27	34.97	150
18.06	65.00	40.39	200
20.18	72.66	45.16	250
22.11	79.60	49.46	300
23.88	85.97	53.43	350
25.53	91.91	57.11	400
27.08	97.47	60.58	450
28.54	102.76	63.85	500
31.27	112.56	69.94	600
33.77	121.57	75.54	700
36.11	130.00	80.78	800
38.30	137.88	85.67	900
40.31	145.13	90.18	1000
42.34	152.42	94.71	1100
44.22	159.19	98.92	1200
46.03	165.72	102.97	1300
47.77	171.96	106.85	1400
49.44	178.00	110.60	1500
51.06	183.83	114.23	1600
54.16	194.97	121.15	1800
57.09	205.53	127.71	2000
59.87	215.60	133.94	2200
62.54	225.10	139.90	2400

B. Cut-out speed=20m/s,p=250Mpa

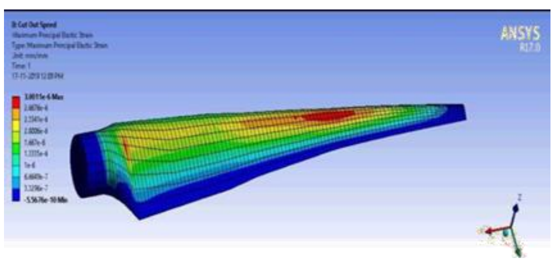
1. Total Deformation at cut out speed



2. Maximum principal stress



3. Maximum Principal Elastic Strain



CONCLUSION

Total deformation observed for cut-out and survival speed ranges from 0.04381 to 0.38611 mm, for 250 and 2200 Pa loading conditions. The glass fiber material loses its elastic properties at survival speed range i.e. at 2200 Pa, and it begins to behave like a brittle material, thereby increasing the rate of failure of the wind turbine blade. As the value of maximum principal strain decreases for higher loading condition, the material begins to lose its elastic properties, and fails due to fracture. Further dealing with materials the use of composite materials such as glass fiber along with vinyl esters provides more strength and the elastic limit of the material also increases consequently. The major area of concern is to make the material in more elastic limit rather than in plastic limit. For excessive loading conditions the materials show direct deformation to the load respectively.

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