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Design and Analysis of Propeller Blade to Augument the Effectiveness in Composite Material

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Abstract **-A windmill is a mill that converts the energy of wind into rotational energy by means of vanes called blades. In current years the increased need for consecutively out of conventional energy sources and there is a tenacious need of developing non-traditional energy sources to undergo the ever accelerating energy needs. Wind turbines deliver a substitute way of breeding energy from the influence of wind. At windy places, wind speeds can achieve sparkling values of 10-12 m/s. Such high speeds of wind can be utilized to bind energy by set up a wind turbine usually having 3 blades.**

The geometry of the blades is made as such that it generates lift from the wind and thus rotates. The lift force generates a moment around the hub and thus the combined torque effort of 3 blades rotates the turbine and generates electricity. Rotational speed of the blades is usually 6 times that of wind speed. Suitable materials for different parts of the blade are taken to see which combination of materials gives better strength.

In this research work, going to take analysis in static structural analysis in the wind turbine blade by using different profile with different material to find out superlative and efficient one blade. Right now in this world is more competitive to make high strength to weight ratio. Here the ultimate aim of this project is to reduce weight of blade which helps to rotate ease with low wind speed. At the same time strength is not compromise one leads to involve this project in structural analysis. Modelling is done with CATIA V5, analysis in ANSYS.

Keywords: Blade, Composite, Glass Fibre, Carbon Fibre and Spar

INTRODUCTION:

Daniel Halladay was the first to design windmills in New England. The majority of modern windmills take the form of wind turbines used to generate electricity. Wind turbines also include a utility box, which converts the wind energy into electricity and which is located at the base of the tower. In these days, composite materials are widely used in varieties of Engineering Application due to its superior Mechanical Properties which have high Strength to Weight ratio, high stiffness, high fracture toughness, high Corrosion resistance and low thermal conductivity and many more. Wind power has been used by mankind ever since they have known to put sails to their boats and canoes. This day, wind powered generators come in wide size ranges that can charge batteries or meet electricity need of a large population. Wind power is the manifestation of converting energy from wind into other useful forms of energy with the help of wind turbines for making electrical power, windmills for mechanical power, wind pumps for water pumping activities/drainage, or sails for propelling ships.

PRINCIPLE OF PROPELLER

- Propeller are based on Bernoulli's principle and Newton's third law
- Propeller works by throwing mass in the opposite direction you want to go, which ,by new tons law produces equal and opposite reaction of you moving
- It based on push and pull concept.

Recently, there is an increased interest to increase strength as alternative composite materials for wind mill. [1] In this research work initially different problems studied, at the very initial stage finite element eigenvalue analysis of tapered and twisted Timoshenko beams was studied which gives the clear idea about tapered and twisted wing. [2] To calculate the fatigue life of a windmill blade, Structural investigation of composite wind turbine blade considering various load cases and fatigue life has been studied. [3] Modal analysis of wind turbine to identify its natural frequencies, damping characteristics and mode shapes. They considered a lot of experimental procedures like impact modal testing technique which resolves flap-wise and edgewise translations and chord rotations and hydraulic shaker. [4] Study of vibration analysis of tapered composite beams used a higher order finite element to solve a Finite Element Model to obtain natural frequencies and mode shapes of the beam under consideration. To study the free un-damped vibrations of beam structures analysis of externally tapered composite beams as well as mid-plane tapered and internally tapered composite beams. [5] On study of tapered laminated composite structures, have elucidated the advantages of dropping off some plies at discrete positions in the laminate to be the structural tailoring capabilities, damage forbearance and moreover their potential for creating substantial weight saving properties in the field of engineering applications. [6] A study concerning innovations in materials processes and structural configurations for application to wind turbine blades in the multi megawatt range. After these detailed studied shape of shape of spar was chosen as rectangle and circle. And to compare with the different materials of composites that is glass fibre and carbon fibre in Ansys.

COMPUTATIONAL WORKS:

In this present research work, modelling was drawn in CATIA V5 with the geometry specification blade length, and chord length was 40mm, and 2.5mm respectively. CATIA is used to model the complex blade geometry as specified.

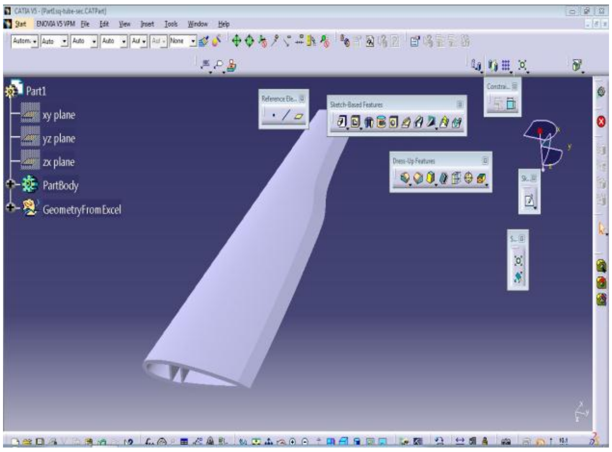

Fig 1.Rectangular spar in propeller

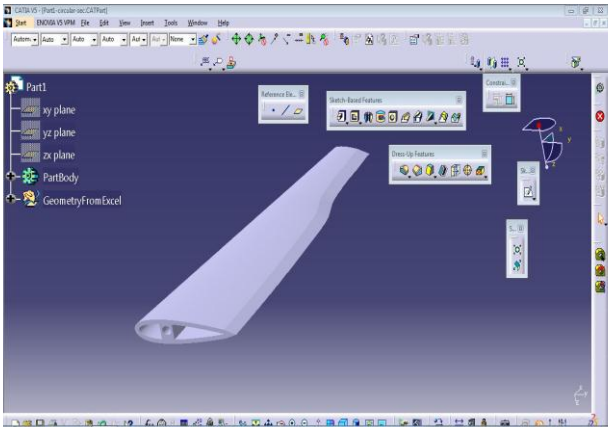

Fig 2. Circular spar in propeller

Chord is the end to end length of the blade cross section. Twist is the progressive rotation of the blade cross-section about its axis so as to increase surface area for lift and drag forces. Skin is the outer covering of the blade, the one that imparts the NACA 23015 shape to it. Spar web is the section provided inside the hollow skin to reinforce it with bending stiffness along with the spar. Then the model was converted in iges file. After finishing the works in CATIA, then iges model was imported in ANSYS. And appropriate boundary conditions were given to the designed circular spar model and rectangular spar model. At the same time different types of fibre material were used that is glass fibre and carbon fibre. These four cases were taken out in this research work to compare the best results of spar shape and composite material. Fig 1 and 2 shows that rectangular section of spar and circular section of spar. After analysing all cases in the pre-processing work then this computational work moved to the result and analysis.

RESULTS AND DISCUSSIONS:

In these work two different types of material was chosen that is glass fibre and carbon fibre with two different shapes of spar i.e., rectangular spar and circular spar. However for the validation of the natural frequencies, materials given were used for the vibration analysis.

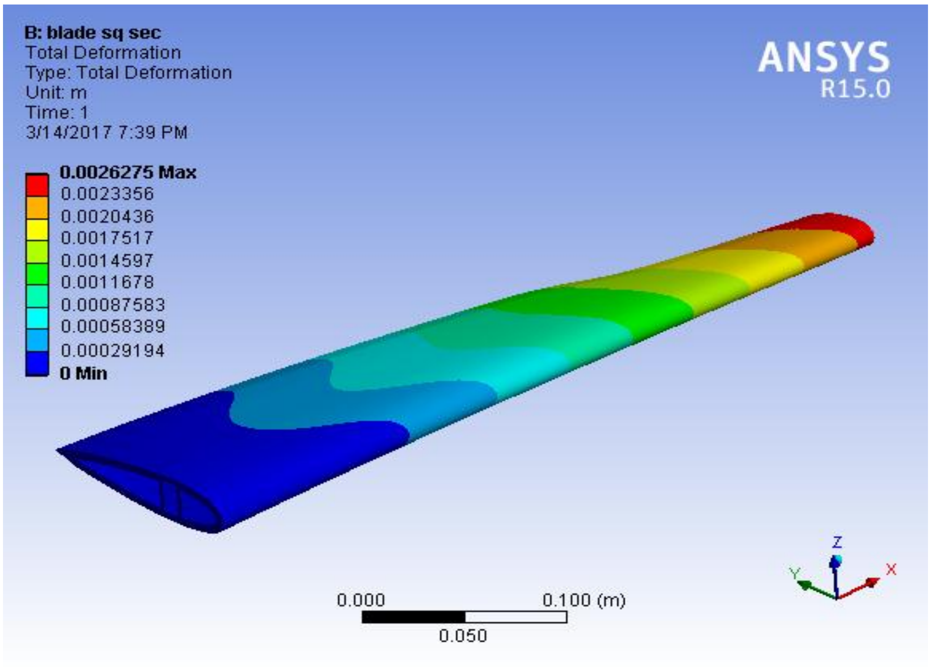

Fig 3. Total Deformation of glass fibre rectangular section

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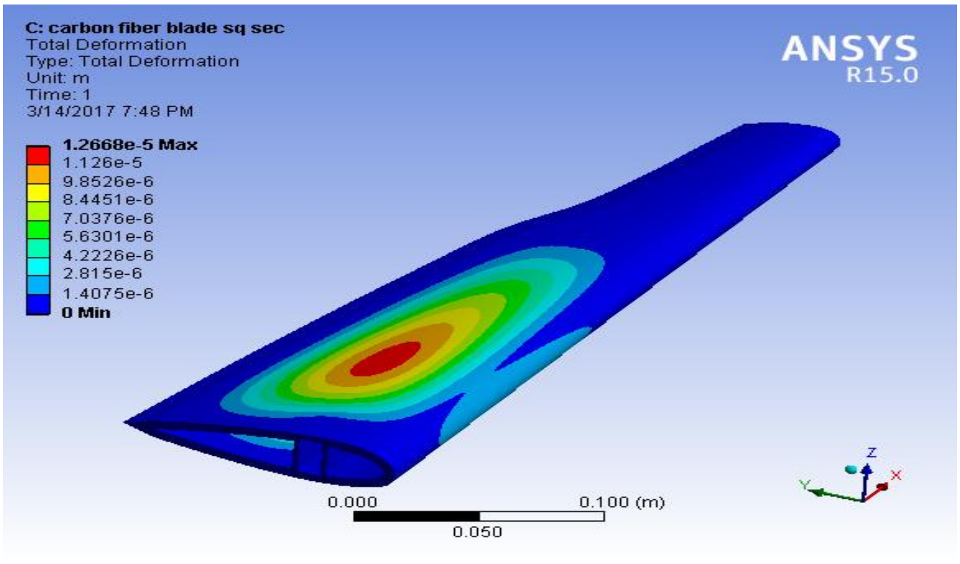

Fig 4. Total Deformation of Carbon fibre rectangular section

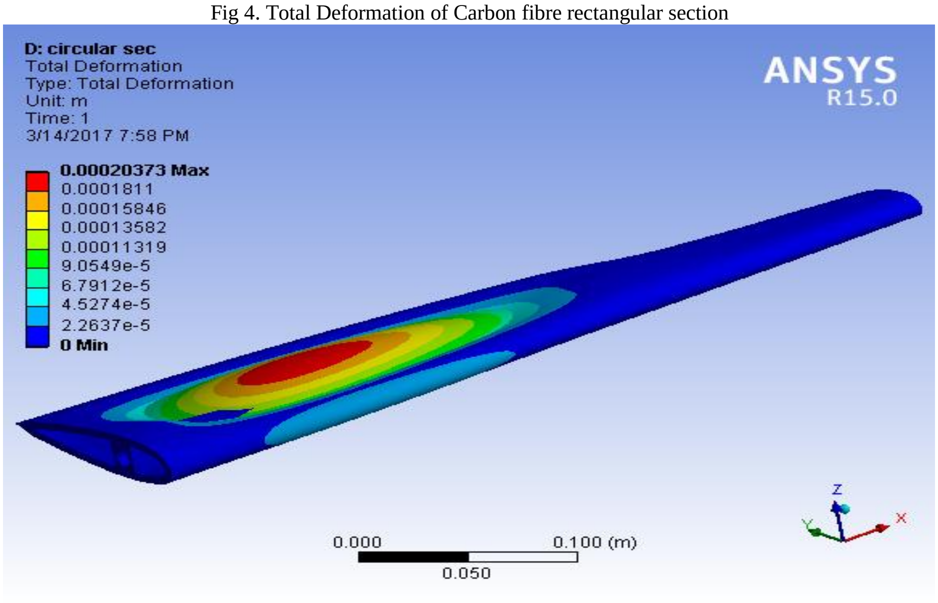

Fig 5. Total Deformation of glass fibre circular section

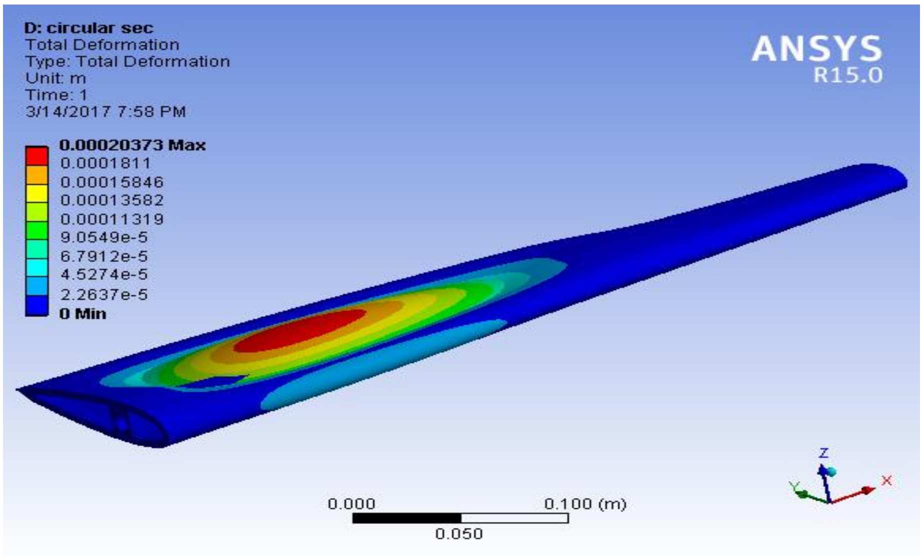

Fig 6. Total Deformation of glass fibre circular section

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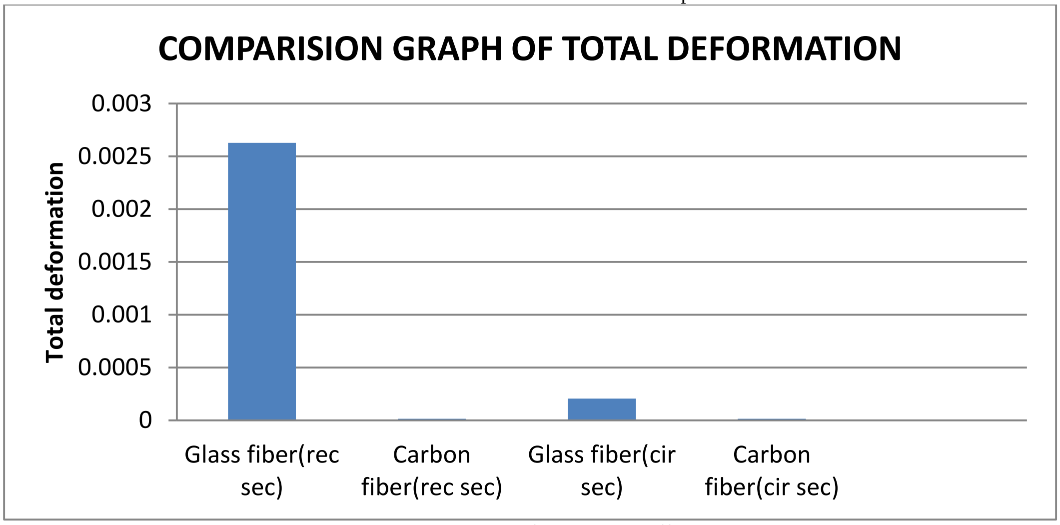
Fig 3, 4, 5, and 6 shows that total deformation of glass fibre rectangle section, total deformation of carbon fibre rectangular section, total deformation of glass fibre circular section, total deformation of glass fibre circular section

The Results which are obtained from the ANSYS software are tabulated like Deformation, Von-Misses Stress and Mass are mentioned in the table, which are mathematically calculated in the table.

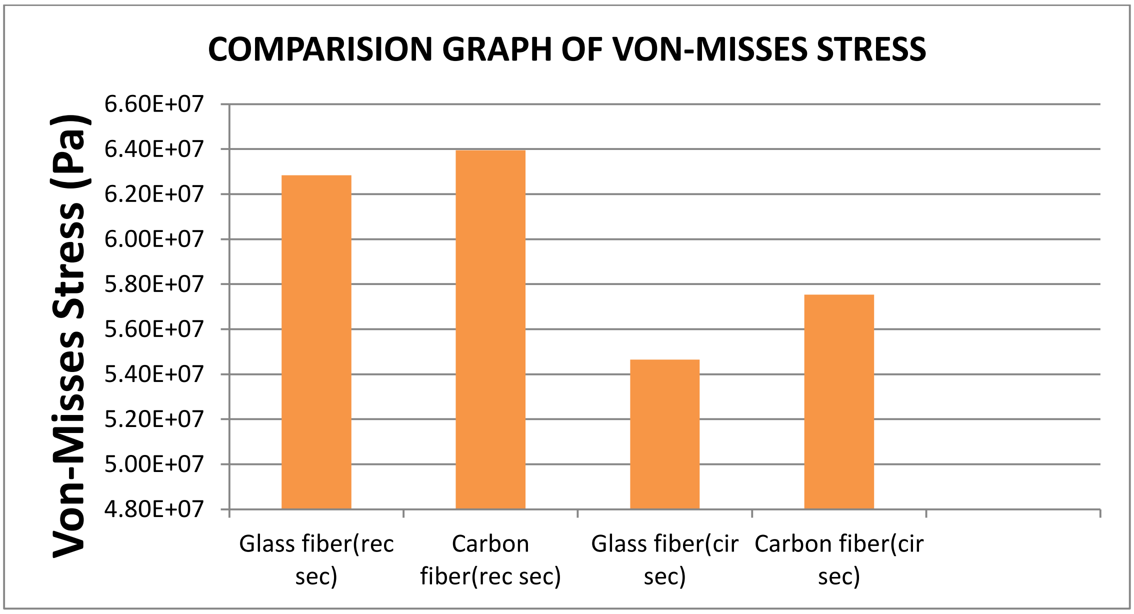
Material		Deformation (m)	Von-misses stress(pa)	Mass (kg)
Glass fiber	(rectangular section)	0.0026275	6.2835e7	0.61395
Carbon fiber		1.2668e-5	6.3951e7	0.57783
Glass fiber	(circular section)	0.00020373	5.4644e7	0.62538
Carbon fiber		1.2631e-5	5.754e7	0.5686

Table 1. Table results of all the composite materials



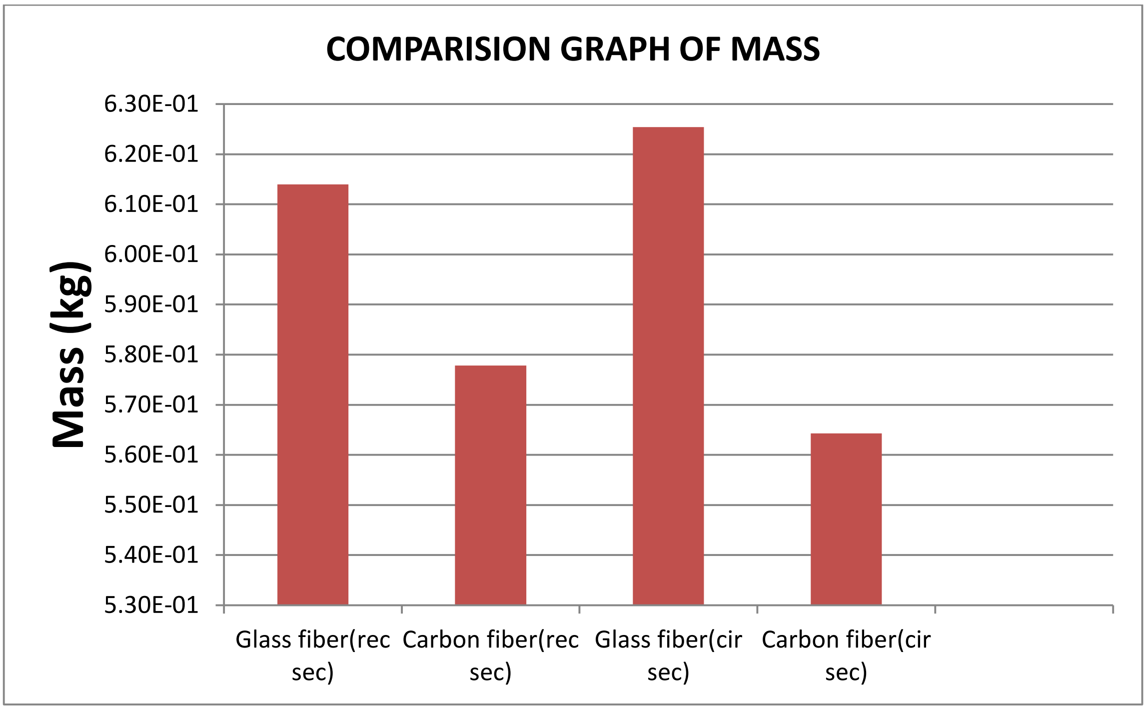
Graph 1. Total deformation in different Composites Materials

From the graph 1 it is observed that, Glass fibre (rectangular section) composite material undergoes a maximum deformation of 0.0026275m and minimum deformation of 1.2631e-5m was observed for Carbon fibre (circular section) composite material.



Graph 2. Von-misses stress in different Composites Materials

From the above graph 2 it is seen that Von-misses Stress of the carbon fibre (rectangle-sec) is having high stresses 6.3951e7 Pa whereas the glass fibre (circle-sec) is having very less 5.4644e7 Pa which is a very good property for the composite materials which are considered in this investigation and it is preferable for the manufacturing the Wind mill Blade.



Graph 3. Mass in different Composites Materials

In the graph 3 the composite materials considered in the research have been plotted from it is clear that carbon fibre (circular section) is having very less weight i.e., 0.5686 kg and which is a good property for preparation of the Wind mill Blade

CONCLUSION:

In this project work, CATIA V5 software was used for designing and modelling of the horizontal axis Wind turbine blades. Wind turbine blade profile NACA 63-421with twist angles of 15º in which the chord length both tip and root was given and then analysed. The Analysis work is carried out by Ansys workbench software.

- The Equivalent Static Strain Analysis results indicates that, carbon fibre (circular section) composite material under goes the minimum deformation of 0.010777mm as compared to the other composite materials, and the maximum deformation of 0.0136mm was observed in carbon fibre (rectangular section) composite.
- The Minimum Von-misses Stress of was observed in carbon fibre (circular section) composite material as compared to the other materials. It is observed that carbon fibre (rectangular section) composite material experiencing huge stress of 6.3951e7Pa.
- Stiffness of carbon fibre composite material is higher as compared to the stiffness of other materials considered in this investigation.
- From strength and stiffness point of view carbon fibre composite materials performing better than the other composite materials considered in this work.
- Based on the experimental observations in terms of strength, stiffness carbon fibre Composite material is recommended.

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