JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Analyzing feasibility of amplitex fibre(Natural fibre) for wind mill blade material (carbon fibre) by ansys Simulation

SHRIKANT CHOUDHARY, Dr. ASEEM C. TIWARI

RESEARCH SCHOLAR,

UIT RGPV BHOPAL.

ABSTRACT

Renewable energy sources play an important role in fulfilling rising global power demand in a variety of ways. Solar and wind energy are two of the most abundant renewable energy sources. Because of its economic compatibility with traditional energy sources, wind energy has become more popular than solar energy. The market for large wind turbines has reached a saturation point. The small wind turbine business is slowly expanding, necessitating reliable and long-lasting technology. Small wind turbines are made up of two main components: the blade and the generator. Many researchers are attempting to improve the performance and reliability of blades and generators.

The objective of this research is to find the optimized alternative natural fiber for wind mill blade as we known the current fiber has some issues their availability, more cost, and the main limitation is non-biodegradable. Currently we use mainly carbon fiber, e-glass fiber for improved strength, low weight, and corrosion resistance among all the parts of a wind turbine, such as blades, hub, gear box, nacelle, and tower. A biodegradable and non-hazardous replacement to windmill blades will be found in this study, and the cost and availability of the material will also be lower and more readily available. Natural fiber-reinforced polymer composites, their characteristics, ingredients, production methods, and flaws will be examined in this study. Ansys will be used in this study to examine the mechanical characteristics of the material, including tensile stress, shear stress, young's modulus, and strength. When all of these studies' findings are combined, we will be able to conclude with confidence which natural fibre is the best substitute in terms of mechanical qualities.

Using wind kinetic energy, a wind turbine generates electrical energy. Nacelle and wind turbine blades, as well as other sections of a wind turbine such as blades, hub, gear box, nacelle, and tower, are often made of glass and carbon fibre for increased strength and reduced weight. These have the most significant downsides.

This research aims to improve the availability, non-biodegradability, health dangers, and manufacturing costs of materials.

These materials are being replaced with natural fibres. It will be examined in this study how natural fibers-reinforced polymer composites are used in wind turbines and what are the requirements for the composites' qualities, ingredients, manufacturing methods, and faults.

Chapter-1

Introduction

1.1 Introduction

In today's society, electricity is a need and a priority. Different techniques of generating electricity have resulted in increased pollution of the planet. There is a pressing need for electricity to be generated from non-conventional sources, such as renewable energy and alternative energy. The use of technology can meet human wants, but it should not have an impact on the system. Human needs. Wind has emerged as a key resource in the production of such clean energy, and it meets human need as an alternate source of power extraction.

Hot air rises and cold air fills the space created by temperature variations over the surface of the Earth. A variety of natural processes are responsible for the wind's ability to blow all across the world. Wind is a plentiful natural energy source that may be exploited due to its continual occurrence, clean nature, infinite supply, and green status.

The earth's surface heats up towards the equator, which causes the air above it to warm up, resulting in stronger winds and lower pressure; as a result, cold air from the poles rushes towards the equator. We call this geostrophic wind. Upper-elevation views reveal this.

The wind in the northern hemisphere blows counterclockwise, whereas the wind in the southern hemisphere blows clockwise as the globe spins, as seen in Fig. 1.1.

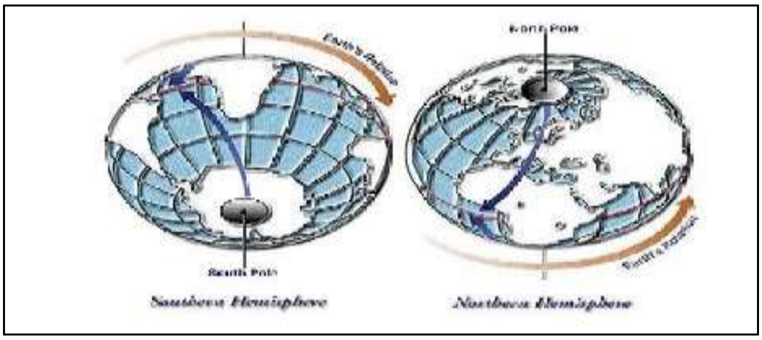
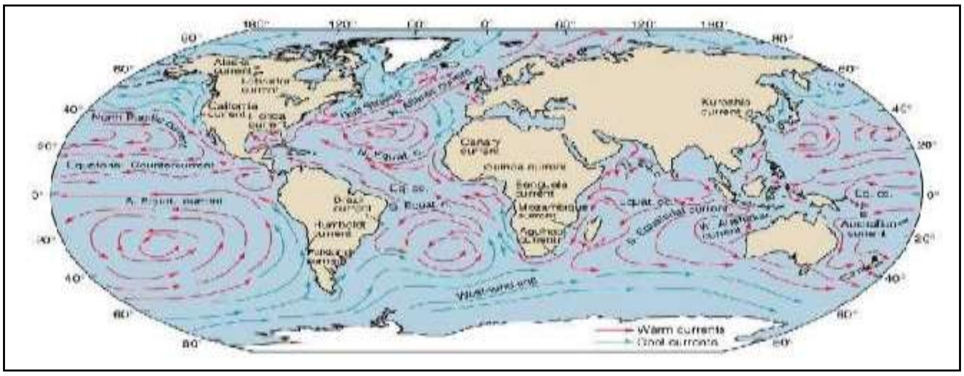


Fig: 1.1 Coriolis Force



I. **Fig: 1.2 Flows of Wind and Currents across the Globe**

1.2 Development of wind energy in India

To a greater or lesser extent, every state save for Rajasthan and Andhra Pradesh has a significant amount of wind energy infrastructure. In terms of wind energy installation, Tamil Nadu has long been at the top of the heap among Indian states. At 7,276 MW, it accounts for 34% of India's total installed wind energy capacity. In second place behind Tamil Nadu is Maharashtra, which has 4,098 MW of wind power capacity. In addition to Gujarat, Rajasthan, and Karnataka, wind energy's share in India has grown significantly. These states have more than 2000 MW of wind energy capacity built in each one. More than 19,500 MW of wind power has been installed. Because of this, the government has now set a goal of adding 2500 MW of capacity per year.

1.3 Purpose of Study

The primary goal of this thesis is to develop an alternative natural fibre material for wind mill blades. It is common practise to use glass and carbon fibres for all of the components of a wind turbine in order to increase its overall strength and durability while also reducing the overall weight. The most prominent drawbacks of this project are: the project's aims are to enhance the availability of resources, as well as their non-biodegradability, health hazards, and production costs.

As an alternative, researchers are looking into using natural fibres. This research article examines the use of natural fiber-reinforced polymer composites in wind turbines, as well as the requirements for the composites, their characteristics, ingredients, manufacturing procedures, and faults; possible future possibilities for their development will also be examined.

Chapter-2

Literature and Review

Section lift coefficient was increased while drag was kept to a minimum by using MEM Microtabs developed by Dt Yen Nakafuji, CpVanDam, RlSmith, and SDCollins [1]. For a sample airfoil, computational and experimental results are compared for fixed and remotely operated tabs, respectively. The findings presented show that Microtabs may be used for active load management with considerable potential.

Wind turbines with an untwisted blade in steady state were simulated numerically by Chalothorn Thumthae and Tawit Chitsomboon [2] to find the best pitch that maximises power production. The blades were fastened to the revolving frame using the rotating frame method. There is good agreement between the computations and the experimental results.

There has been a lot of research done on the angle of attack for four different blade profiles, Re Numbers, and the relationships between lift and drag rates. [3]. A computer programme has been developed to determine lift, drag, moment and minimum pressure coefficients for Snack 2.0. 3o and 9o were found to be the most convenient angles of attack based on the greatest sliding rates available for all studied blade profiles. Using the data, the largest drag rates are discovered at the Re 20000 level

Nazmi Izli, Ali Vardar, and Ferhat Kurtulmu [4] have used the snack 2.0 computer software to do multiple simulations to obtain the lifting and drifting coefficients for 14 distinct Reynold values, four different NACA profiles. The most convenient angle of attack and 14 various Reynold Numbers, lifting numbers and angle of attack have been revealed and shown in a chart form. To that end, it was discovered that the lifting and drifting rates were correlated for the 14 different Reynold numbers.

An airfoil developed by SHEN Zhen-hua and Yu Guo-liang [5] was utilised in the blade model creation and a tiny low speed tunnel was employed to perform a range of installation angles between 6-14oC and a wind velocity of 8-15 m/s. A gurney flap improves the wind power usage factor of the tested wind turbines in all situations.

Physical approaches, including boundary layer theories and wind tunnel tests, were combined with computer simulations using CFD to study how wind energy collection may be improved at low wind speeds. [6] The findings were published in the Journal of Wind Energy Research. Validation of a CFD model and optimization of a Scoop design. Wind turbine power production is increased by increasing the air flow velocity. There is strong agreement with the CFD model for the development of power curves that have been created experimentally

Full-scale turbine blade aerodynamic blades and existing modelling approaches were studied by Scott J Schreck and Michael C. Robinson [7] in order to better understand the physical and numerical factors that affected modal performance.

They looked at the possibilities of boosting turbine blade efficiency at higher wind speeds while preserving efficiency at lower wind speeds by selecting appropriate air foil cross sections based on low approaching wind speed and provided constant rotation rate by RS Amano and R.J Malloy[8]. Higher wind speeds need a swept blade profile, thus that is what they used it for! Analysis of performance was carried out by CFD.

Wind tunnel Aeroacoustic studies carried out in the open-jet test section on a typical small wind turbine blade were detailed by P. Migliore [9] in his thesis. Tim Fischer [10] investigated the impact of the integrated design of the rotor-nacelle-assembly on achieving the optimal structure at a lower cost. Integrating aerodynamic and hydrodynamic load reduction with a turbine's features and control allows for significant reductions in fatigue loads.

T. K. Barlas and G. A. M. Van Kuik [11] studied active rotor control and smart structures for load reduction. The purpose of the study is to present an overview of the current state and future directions of the specific research field, which includes the specifications of unstable loads, contemporary control for load reduction, and detailed active aerodynamic control. Progress is being made in terms of feasibility, as well as early performance evaluations and unique computational and experimental research methodologies.

W. Devenport, R.A. Burdisso, H. Camargo, E. Crede, M. Remillieux, M. Rasnick, and P. Van Seeters [12] carried out the research work to improve the understanding of wind turbine Aeroacoustics.

According to Indian wind conditions, Nitin Tenguria [13] has devised an optimization approach for a VESTAS 1.65 MW horizontal axis wind turbine's HAWT blade. The optimization approach was created using BEM theory. These results have been interpreted in light of the airfoil's characteristics (NAC A634221). Variable parameters like lift and drag coefficient, chord distribution, and twist distribution may be simulated using a computer programme. Comparing our findings with the literature, we discovered that our findings were in line with those of other studies.

S. Lain, B. Quintero, and Y. Lopez [14] explored the aeromechanical assessment of the HAWT Blade utilising a technique based on the combination of an aerodynamic module, which gives the three-dimensional distribution on the blades. Pressure forces are used as input data for calculating blade deformation and the distribution of strain and stress over the blade. Combining three-dimensional non-linear lifting surface theory techniques, the aerodynamics module was developed.

The distributions of chord and twist angles in wind turbine blades have been delineated by Juan Mendez and David Greiner [15] Based on the Weibull wind distribution, the distributions are estimated to maximise the mean predicted power. Chord and twist distributions can be improved using BEM theory. Using the Riso test turbine, the implementation is tested by comparing its predicted power output to the actual data.

Newly designed, constructed blades employing NREL S822, S823 airfoils were tested by Donny R. Cagle, Anthony D. May, Brian D. Vick and Adam J. Holman [16]. Using the new blades, the system had a maximum power coefficient of 0.41.

Water pumping capacity was increased by two times while using new blades compared to Bergey blades.

Studying the natural frequencies of rotor blades of the NACA 4415 and NASA / Langley MOD series wind turbines has been done by Tufan Coban, K. Turgut Gursel, and Aydogan Ozdamar. [17] The natural frequencies were determined using Rayleigh's approach, and the finite element method was then utilised to calculate them. Using stimulation from outside sources, it is possible to determine the resonance frequencies of the two rotor blades as well.

Blade Element and Momentum Theory were used to analyse the rotor aerodynamics of a wind turbine by K.R. Ajao and I.K. Adegun [18]. The study material is focused on the mechanics of wind turbine power extraction in both the near and distant wake areas. Generalized Fokker-Planck equation is used to represent turbine power as a partial differential equation fulfilled by the probability distribution function.

L.J. Vermeer, J.N. Sorensenb, and A. Crespo [19] examined the aerodynamics of horizontal axis wind turbine waves. This paper reviews the experimental and numerical efforts on wind turbine power extraction physics, focusing on measurements in controlled environments.

It was developed by a group of researchers led by Dr. S. P Vendan, who worked with colleagues S. Aravind Lovelin, M. Manibharathi, and C.Rajkumar to harness the low-speed wind in metropolitan areas. The NACA 63415 Airfoil is evaluated for wind turbine blade analysis. STAR-CCM+ is used for CFD study at various angles of attack, from 00 to 160. For low Reynolds numbers, the pressure distributions are displayed and the coefficient of lift and drag values are determined. The results suggest that NACA 63415 is suitable for use on wind turbine blades.

On various airfoil measurement sets, Franck Bertagnolio, Niels Srensen, Jeppe Johanson, and Peter Fuglsang [21] conducted tests using the 2D Navier-Stokes solver EllipSys2D and confirmed the results. In a research that correlated available data and categorization, the results showed low quality because of transition modelling to a considerable extent. For future airfoil design, the EllipSys2D numerical code and transition modelling are recommended for developing future processes.

Richard E. Wirz and Perry M. Johnson [22] devised a multiplane inboard design for wind turbine blades that provides an appealing aero-structural performance. Two planes are used to compare the cross-sectional characteristics of thick monoplanes with those of a thin monoplane. The lift-to-drag ratio of a biplane is shown to be much higher than the lift-to-drag ratio of a thick monoplane using numerical modelling. At long last, these findings show that the biplane blade method is a promising design for the upcoming portion of wind turbine blades.

Research gap

Wind turbines using savonius rotors, which are common in India, are being studied to see whether they may have their performance improved by using different reducer angles and lowering the opposing wind pressure on the rotors. The wind turbine must be self-starting in order to fulfil the standards and 71 wind velocity variation. As fossil fuels continue to rise in price, research into unconventional renewable energy sources will be cost-effective and financially lucrative. The generation of wind energy does not produce any emissions. The Vertical Axis Wind Turbine is simple to use, user-friendly, and provides enormous energy supplement advantages.

2.5 Research Objective

The objective of this thesis is to determine the impact of wind mill blade material on environment and how much electricity produce as we know that the mainly used material in wind mill blade is carbon fiber, aramid fiber and eglass fiber such components are non-biodegradable. This research aims to replace these materials with natural fibres because of their lack of availability, non-biodegradability, health hazards, and high manufacturing costs.

CHAPTER- 3

MATERIALS AND METHODS

3.1 Introduction

Energy from the wind is converted into electricity by use of an apparatus known as a turbine. Glass and carbon fibres are used in the nacelle and blades of wind turbines because they are lighter, more corrosion resistant, and more durable. This research aims to replace these materials with natural fibres because of their lack of availability, non-biodegradability, health hazards, and high manufacturing costs. In this study, the use of natural fibers-reinforced polymer composites in wind turbines, their needs, characteristics, components, manufacturing processes, and faults will be evaluated; possible future paths of their development will also be explored.

1. Natural Fibres

There are several types of natural fibres: those that are made from plants, animals, minerals, or geological processes; and those that decompose over time. As a result, they may be spun into filamentous thread, threaded, or woven fibres. They can also be matted, knitted, or bound in many other ways. There is no need for the development or reformation of natural fibres, as they are received from natural sources and do not require it. Cellulosic fibres derived from plant seed hairs, stems, and leaves; protein fibres derived from animal hair, fur, or cocoons; and the mineral asbestos are the economically important natural fibres.

a. A lot of power (to withstand even extreme winds, as well as gravity load),

b. a high level of fatigue resistance and dependability (to ensure the stable functioning for more than 20 years and 108 cycles),

c. a light weight (to reduce the load on the tower, and the effect of gravitational forces)

d. Enhanced rigidity (maintain the blade's aerodynamically ideal form and position when it is in use, as well as the necessary distance between its tip and the tower).

2. Fibre selection

Plant, animal, or mineral-based fibers are the most frequent types of fibers. Cellulose is the primary structural component of plant fibers, whereas protein is the primary structural component of animal fibers. Many nations have outlawed the use of mineral-based natural fibers that originate from the asbestos group of minerals because of health concerns (carcinogenic by inhalation/ingestion). Generally, plant fibers have higher strengths and stiffnesses than animal fibers, which are more easily accessible. If you are looking for something that is both strong and flexible at the same time, silk may be your best choice [6]. Consequently, the utilization of plant-based fires in composites with structural requirements is the subject of the present investigation. Furthermore, plant fiber may be cultivated in a wide range of climates and collected in a very short time.

Fibers containing more cellulose and aligned in the fiber direction, such as flax, hemp, kenaf, jute and ramie, are more likely to perform better than those containing less cellulose and positioned perpendicular to the fiber direction. Composition and structure of natural fires, as well as the type of fiber and how it is grown and harvested and how it is extracted, are all factors that have an impact on the qualities of natural fires.

3. Matrix selection

A fibre-reinforced composite is only as strong as its matrix. Protecting the surface of the fibres from mechanical abrasion and transferring load to the fibres are all benefits of this coating. Polymeric matrices are the most often utilised in NFCs because they are light weight and can be produced at low temperatures. Matrixes containing natural fibres have been made using both thermoplastic and thermoset polymers. [44].

- **Interface strength**

As a result of the use of fibres that have not been processed, natural fibres are ecologically benign, but they also have a number of limitations because they are derived from renewable sources. These drawbacks include differences in quality, significant moisture absorption, and low thermal stability of the raw fibres.

- **Fibre orientation**

For composites, fibre alignment parallel to the direction of load application often results in the greatest mechanical characteristics [85–87]. [88–90]. It is more difficult to align natural fibres, on the other hand, than it is for synthetic fibres that are continuous. It is possible to align injection-molded parts to a certain degree depending on the matrix viscosity and the mould design Prior to matrix impregnation, long natural fibre can be carded and manually put in sheets to achieve higher degrees of fibre alignment.

3.2 Material Description

1.2.1 Amplitex fiber-

High-performance grid textiles composed of flax yarn based on proprietary powerRibs technology have been developed by ampliTex. During manufacture, flax yarn placement is managed to provide a mesh structure that is tailored to the use at hand.

Mechanical qualities are matched to the final composite material by adjusting the flax fibre quality, thickness, and twist of the yarns. This material increases the buckling resistance of hollow structures by three times the flexural stiffness of flat and curved surfaces.

Fig- Amplitex plant

Fig- Amplitex fiber

Properties

- Improved safety with non-catastrophic crash behaviour.
- effective replacement for carbon fibre
- High vibration damping, explicit twisting firmness and exhaustion obstruction.
- Novel design options – colouring and natural translucency.
- Radio transparency.

Manufacturing with prepreg:

- As normal, insert your prepreg fabrics into the mould.
- Make sure that the prepregs have a little extra resin in them (about 200 g/m2), or else put a resin layer on them
- Dry powerRibs should be placed on top of the pre-fabricated materials.
- Place the vacuum bag (extremely flexible, self-releasing) directly on the cloth, without the use of any peel-ply or flow medium.
- In order to pull the vacuum, the ribs first circulate air and then absorb excess resin from the prepreg.
- The ribs can also be pre-impregnated before being applied to the cloth.

Company that manufactures

In high performance applications from racing to space, Bcomp Ltd.-Bcomp is the premier source of natural fibre reinforcements.

The firm was founded in a garage in 2011 with the goal of developing lightweight, yet high-performance skis. They have been embraced by some of the most prominent personalities in freeride skiing.

Located in: Bluefactory Fribourg-Freiburg SA

Address: Pass. du Cardinal 1, 1700 Fribourg, Switzerland

Method

Ansys software simulation

Ansys- Customers across the world can purchase and use the company's CAE/multiphysics engineering simulation software, which it creates and promotes.

Throughout the product lifecycle, Ansys creates and distributes engineering simulation software. Ansys This programme is used to simulate computer models of buildings, electronics or machine components in order to examine the properties of toughness, elasticity and temperature distribution in addition to electromagnetism and fluid movement. Ansys is a tool for predicting how a product would perform under certain conditions, without the need to create prototypes or do crash testing on actual items beforehand.

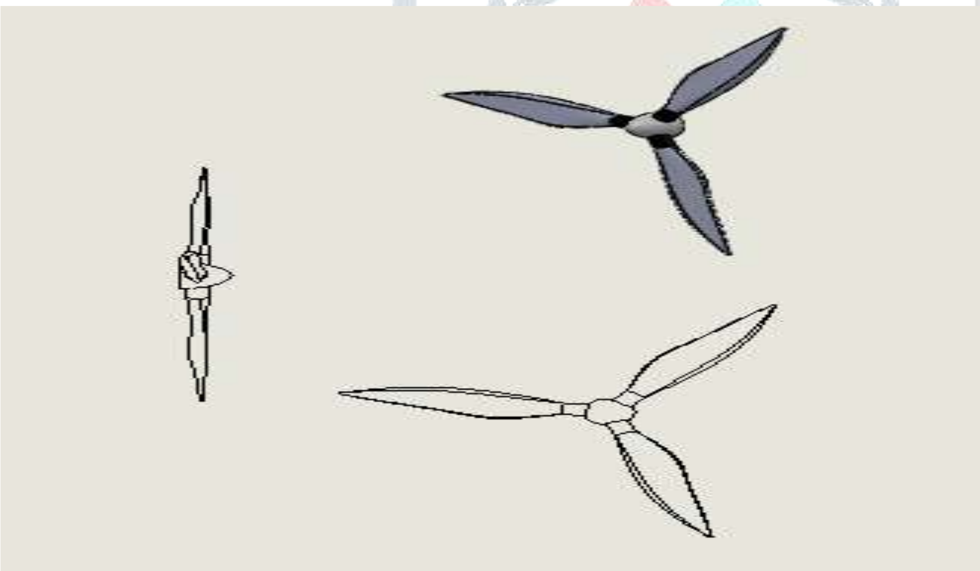
Chapter-4

Result and Discussion

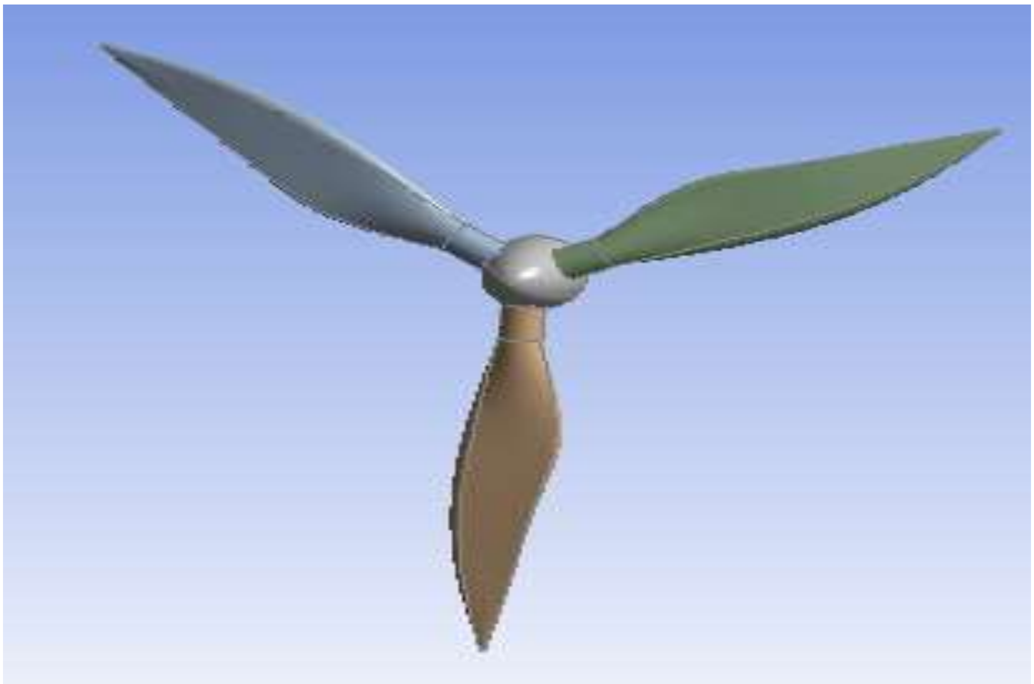
4.1 Analysing of current used material

1. Design of wind mill blade by Carbon fiber (3D)

Given: - Dimensions of wind turbine blade

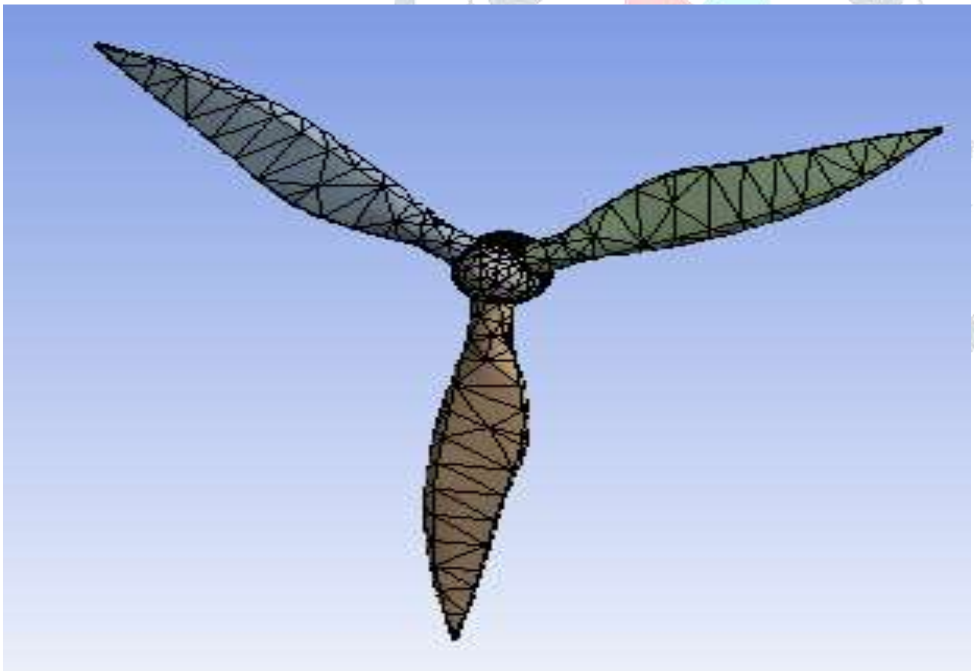


Step 1- Geometry



Step 2- Meshing

1) Element size is 24mm   Default meshing



Step 3 – Setup

Boundary condition

1) One end Fixed

2) Rotational Velocity of 19 rad/s is applied about X- axis

3) Material is taken as Carbon Fiber (230 GPa)having

Density = 1800 kg m^-3

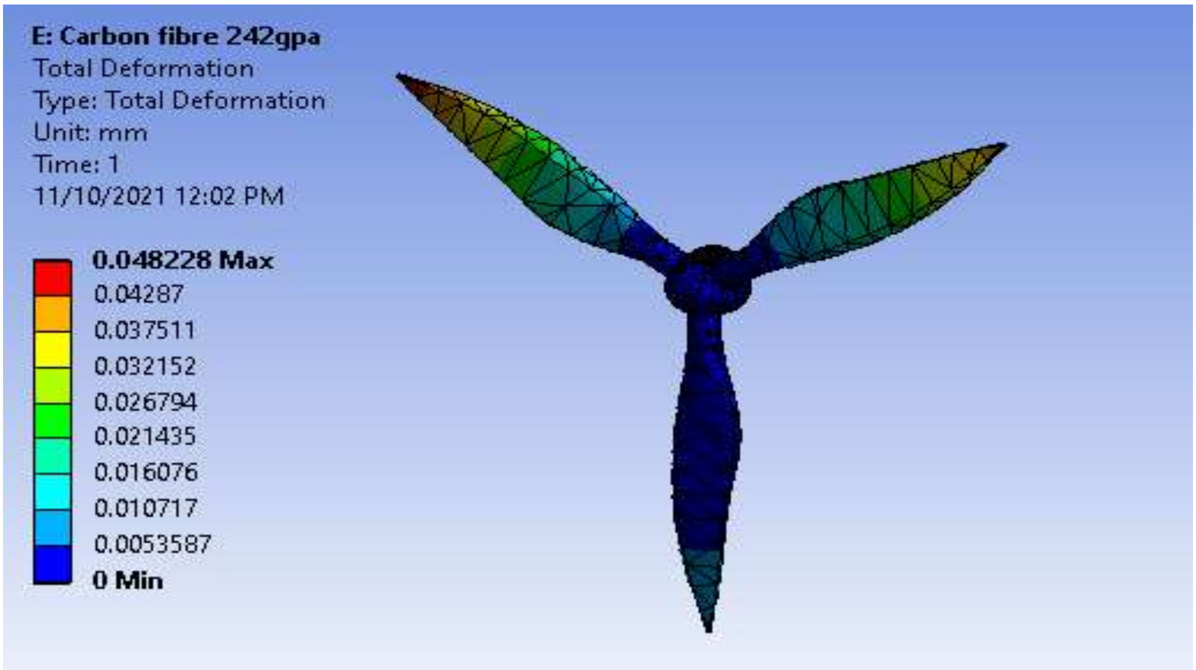
Young's Modulus = 2.3E+05 MPa

Poison's ratio = 0.2-0.4

Bulk Modulus = 4.6606E+09 Pa

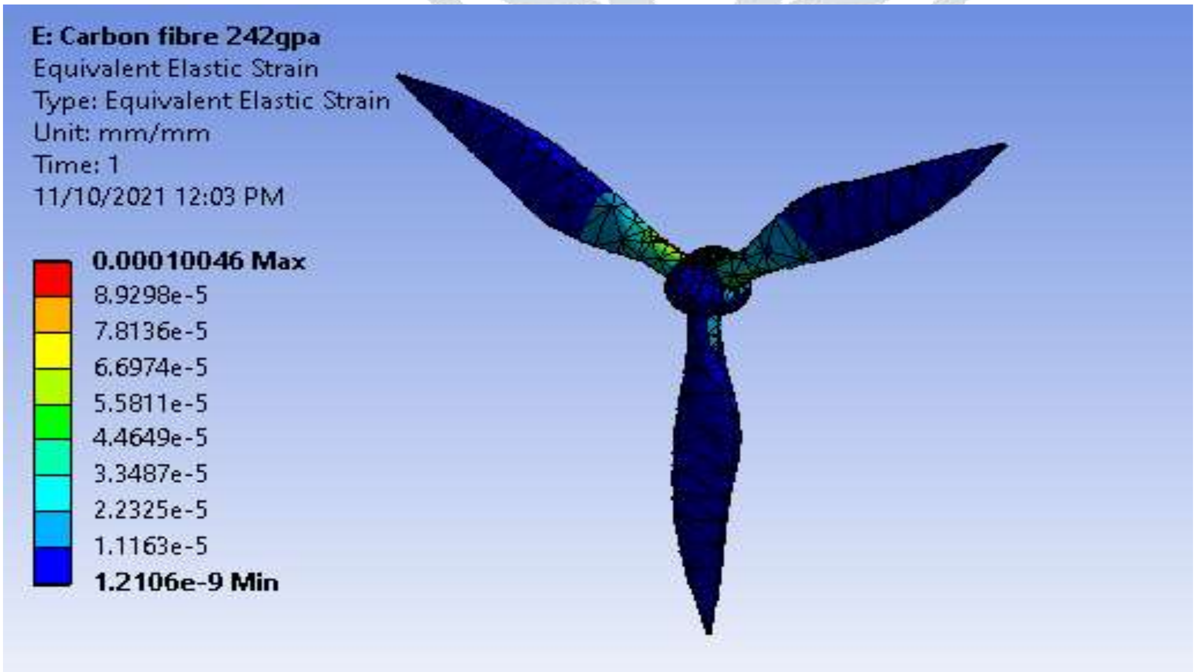
Shear Modulus = 9000 MPa

Step 4- Solution and result



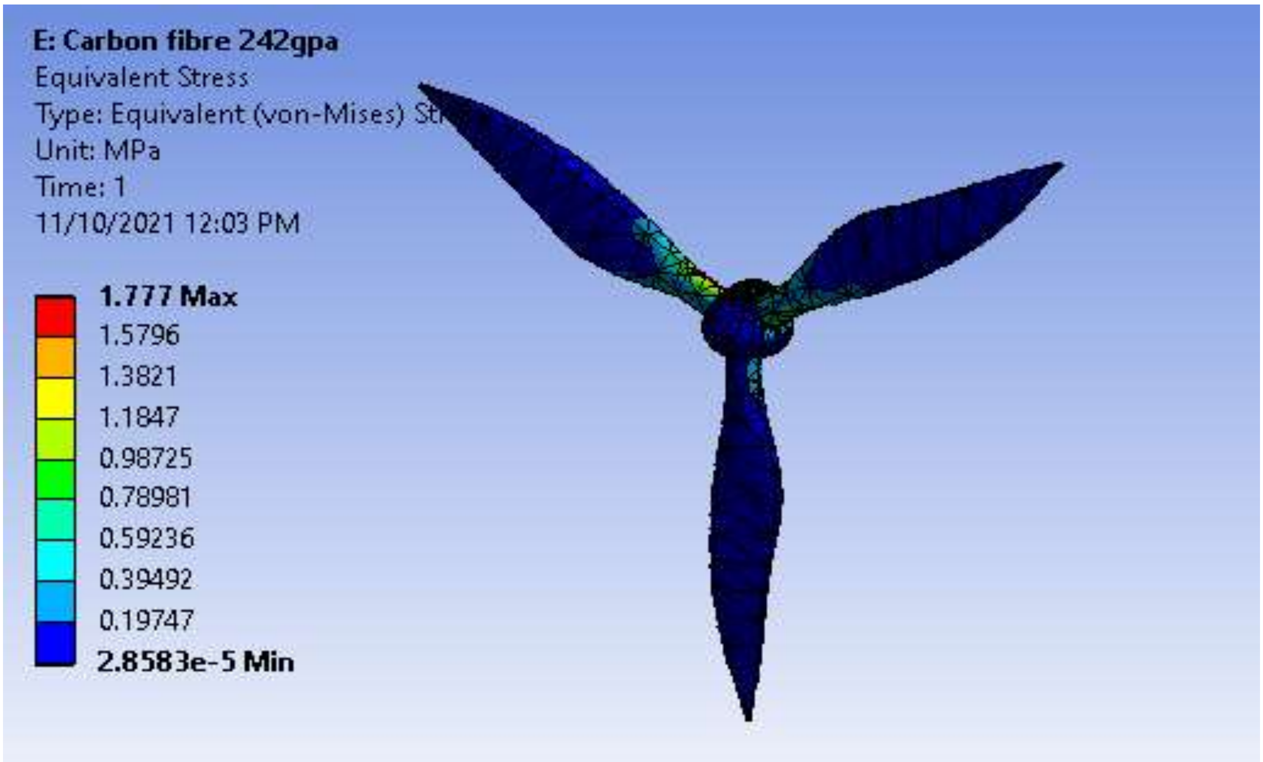
Max. Deformation = 0.048228 mm

Min. Deformation = 0 mm



Max. Strain = 0.00010046 mm/mm

Min. Strain = 1.2106e-9 mm/mm



Max. Stress = 1.777 N/mm2

Min. Stress = 2.8583e-5 N/mm2

Conclusion- As all the values of stress are below the value which is given for material so our design is safe.

Natural fibre

1. Design of wind mill blade by Amplitex Fiber (3D)

TABLE 14

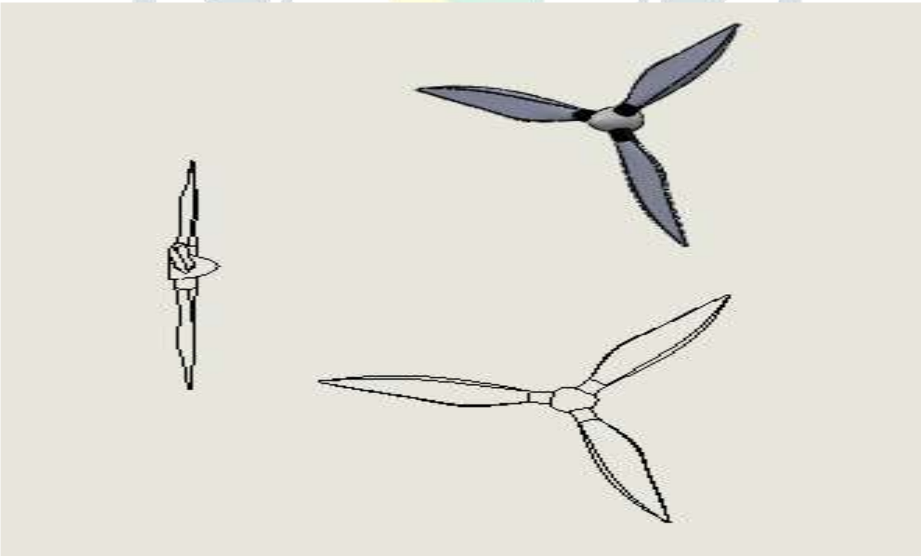
Unit System	Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

Given: Dimensions of wind turbine blade

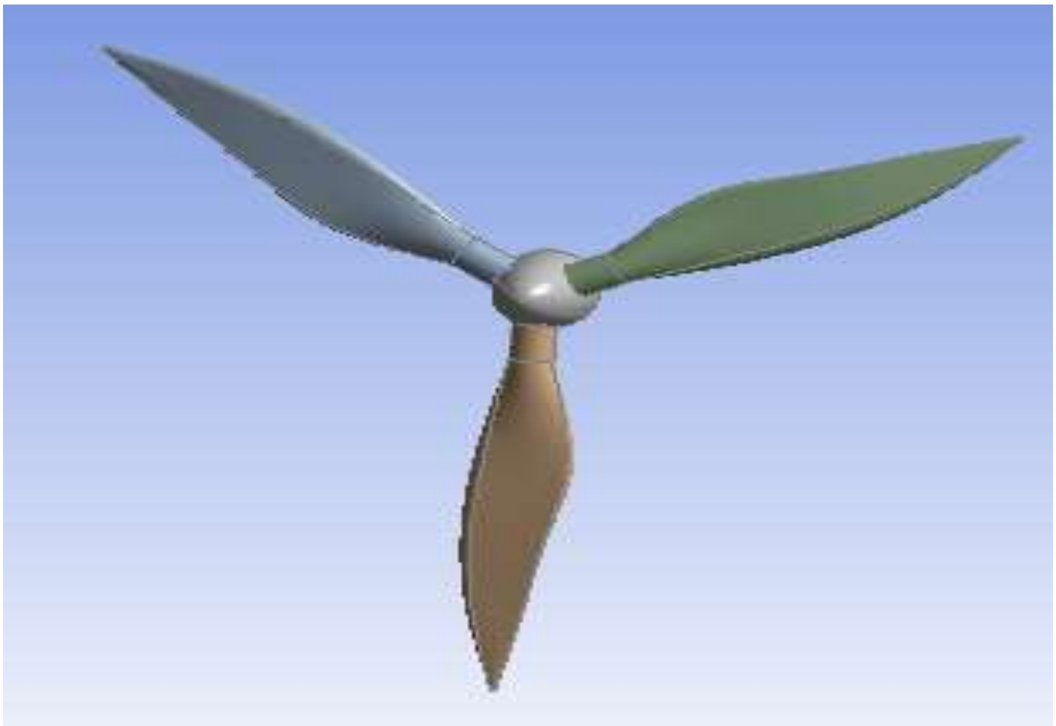
Table 15

Bounding Box	
Length X	44.547 mm
Length Y	364.18 mm
Length Z	338.48 mm
Properties	
Volume	1.4793e+005 mm^3
Mass	0.19971 kg
Scale Factor Value	1.
Statistics	
Bodies	4
Active Bodies	4
Nodes	10580
Elements	5576
Mesh Metric	None
Update Options	
Assign Default Material	No
Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Independent
Parameter Key	ANS;DS
Attributes	No
Named Selections	No

Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	Yes
Compare Parts On Update	No
Analysis Type	3-D
Mixed Import Resolution	None
Clean Bodies On Import	No
Stitch Surfaces On Import	Yes
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

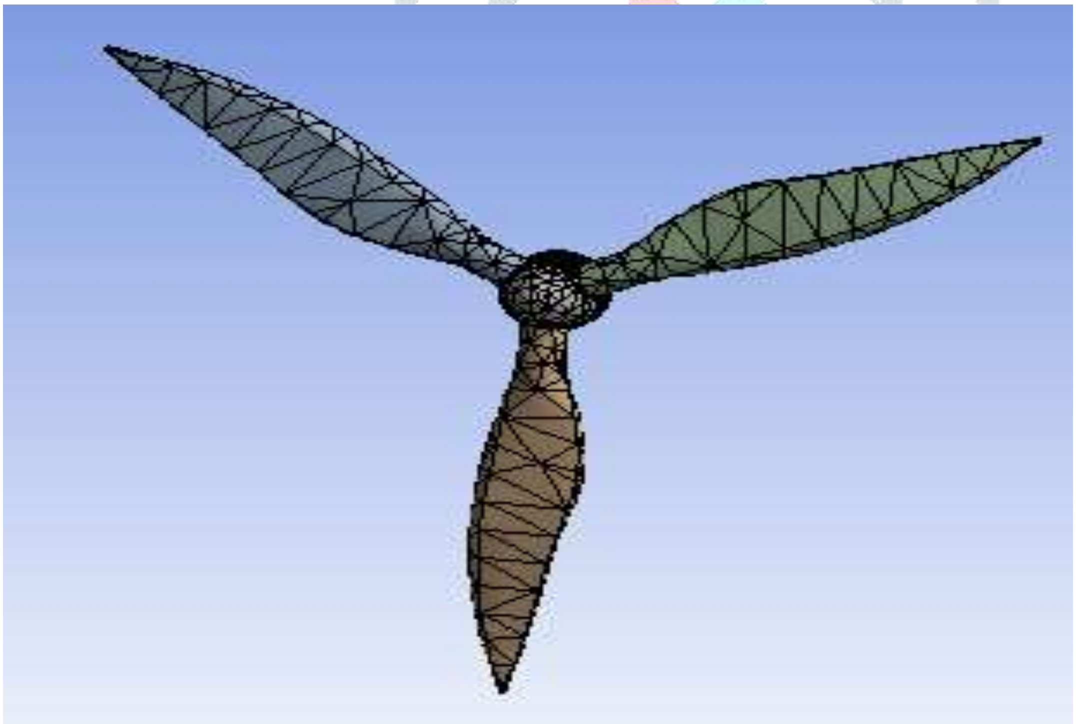


Step 1- Geometry



Step 2- Meshing

1) Element size is 24mm Default meshing



Step 3 – Setup

Boundary condition

1) One end Fixed

2) Rotational Velocity of 19 rad/s is applied about X-axis

3) Material is taken as AmpliTex 5031-2 having

Density = 1350 kg m^-3

Young's Modulus = 60000 MPa

Poison's ratio = 0.3

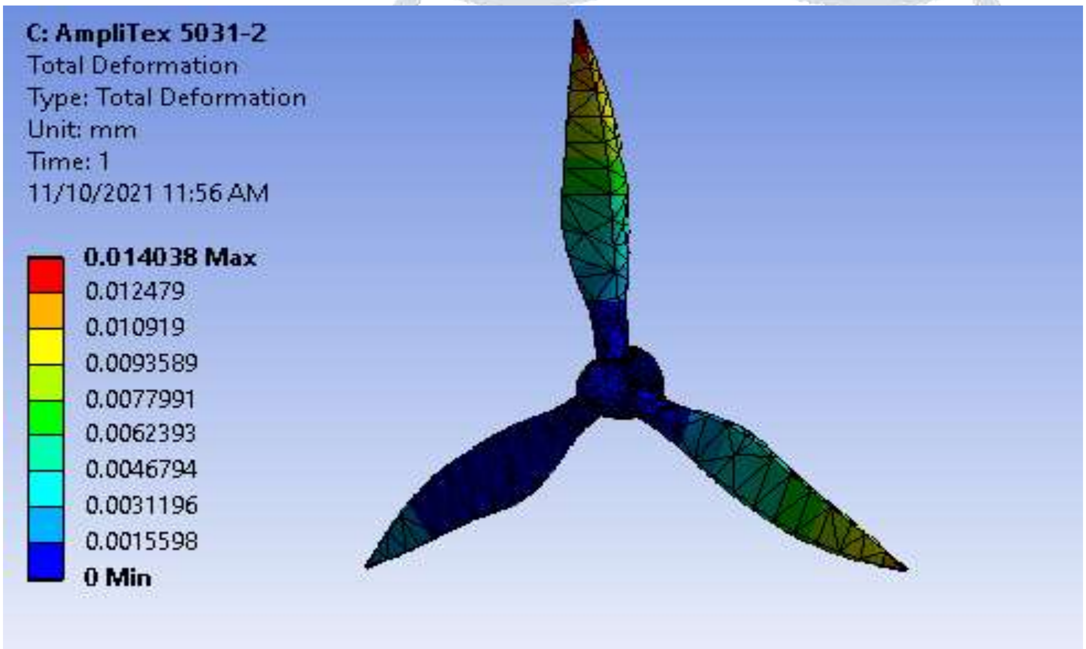
Bulk Modulus = 5 E+10 Pa

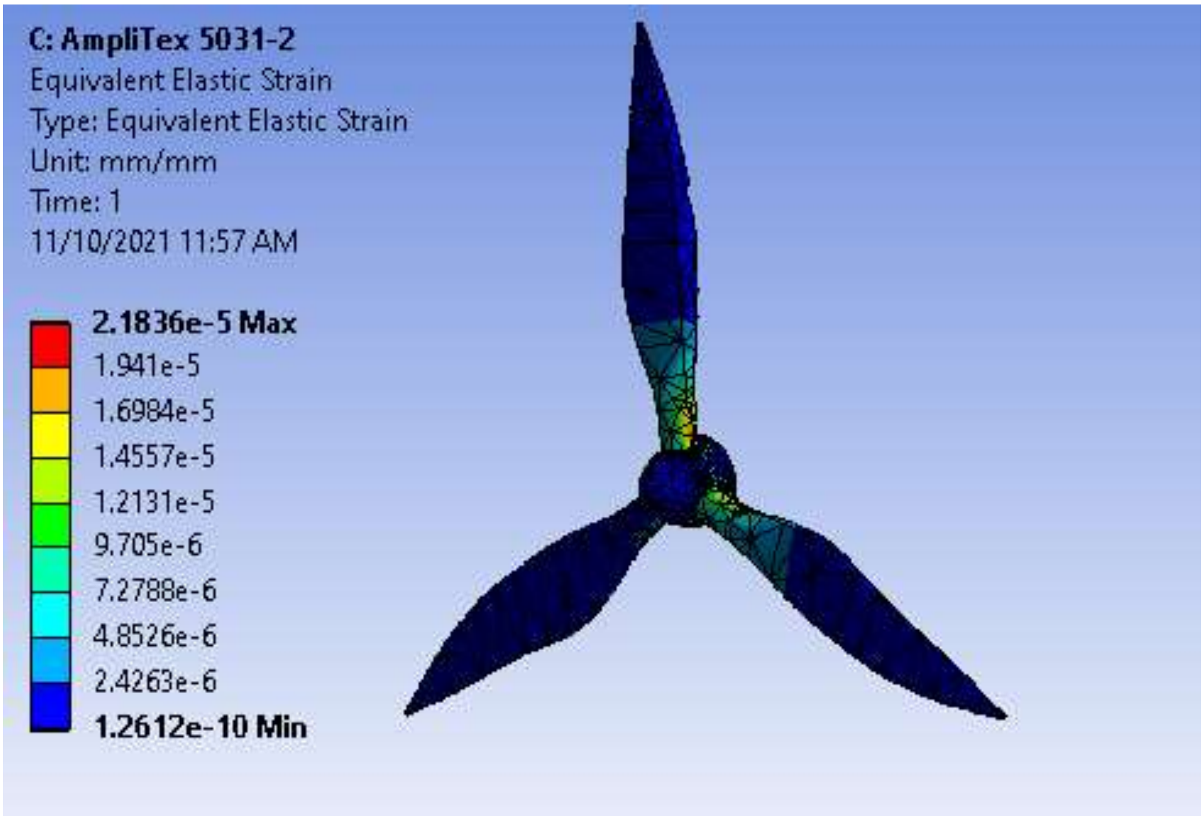
Shear Modulus = 23077 MPa

Step 4- Solution and result

Max. Deformation = 0.014038 mm

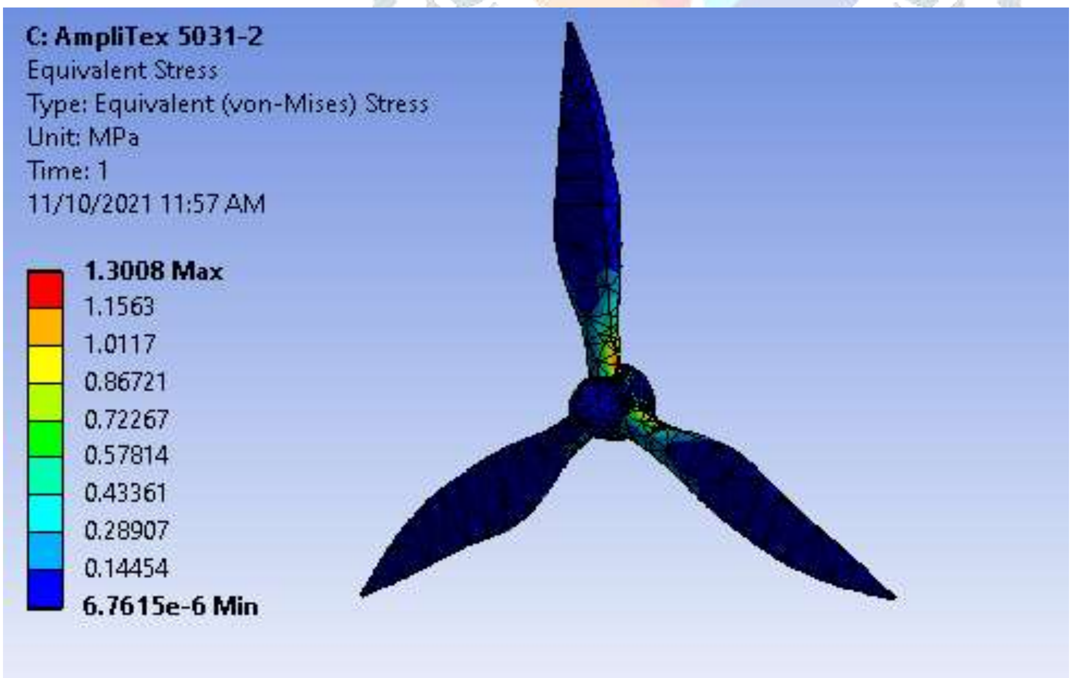
Min. Deformation = 0 mm





Max. Strain = 2.1836e-5 m/m

Min. Strain = 1.2612e-10 m/m



Model (C4) > Static Structural (C5) > Solution (C6) > Equivalent Elastic Strain

Table 16

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]	Average [mm/mm]
1.	1.2612e-010	2.1836e-005	2.263e-006

FIGURE 17

Model (C4) > Static Structural (C5) > Solution (C6) > Equivalent Stress

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1.	6.7615e-006	1.3008	0.12827

TABLE 18

AmpliTex 5031-2 > Isotropic Elasticity

Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
60000	0.3	50000	23077

TABLE 19

AmpliTex 5031-2 > Density

Density kg mm^-3
1.35e-006

TABLE 20

AmpliTex 5031-2 > Color

Table 21

Red	Green	Blue
184	235	197

Max. Stress = 1.3008 N/mm2

Min. Stress= 6.7615e-6 N/mm2

Conclusion

As all the values of stress are below the value which is given for material so our design is safe

4.2 Comparison of currently used material and nature fiber

1. Comparison Between Carbon & AmpliTex 5031-2

S. No	Result	Carbon Fibre	AmpliTex
1	Total Deformation (mm)	0.048228	0.014038
2	Stress (N/mm2)	1.777	1.3008
3	Strain (mm/mm)	0.00010046	2.1836e-5

Chapter-5

Conclusion

It is critical for human life and societal progress that energy be generated, yet doing so without harming the environment is the greatest challenge of the twenty-first century. Using renewable energy sources can help overcome this issue. In terms of renewable energy, wind is the best. Renewable sources of energy such as wind have the potential to replace fossil fuels since they are non-polluting, nondepleting, and unrenewable. Using sustainable energy is really about reducing greenhouse gas emissions and pollution. There is no doubt that wind power is the fastest-growing alternative energy source, however the materials utilised in wind turbine components are not very ecologically friendly.

References:

[1] Yen Nakafuji. et al "Active Load Control for Airfoils using Microtabs", a Journal of Solar Energy Engineering, Volume 123, Issue 4, 282-289, November 2001.

[2] Chalothorn Thumthae and Tawit Chitsomboon, "Optimal Pitch for Untwisted Blade Horizontal Axis Wind Turbine", The 2nd Joint International Conference on Sustainable Energy and Environment (SEE 2006), November 2006.

[3] Ferhat Kurtulmus. et al "Aerodynamic Analyses of Different Wind Turbine Blade Profiles", Journal of Applied Sciences 7(5), pp 663670, 2007.

[4] Nazmi Izli . et al, "A Study on Aerodynamic Properties of Some NACA Profiles Used on Wind Turbine Blades", Journal of Applied Science, Vol.7, pp 426-433, 2007.

[5] SHEN Zhen-hua, YU Guo-liang, "Influence of Airfoil's Camber on the Performance of Wind Turbines", Journal of Power Engineering, ISSN:1000-6761.0.2007-01-029.

[6] Wang. et al "The Methodology for Aerodynamic Study on a Small Domestic Wind Turbine with Scoop", a Journal of Wind Engineering and Industrial Aerodynamics, Volume 96, Issue 1, pp, 1-24, January 2008.

[7] Scott. et al "Horizontal Axis Wind Turbine Blade Aerodynamics in Experiments and Modeling" October 2008.

[8] Amano, R.J. Malloy., "CFD Analysis on Aerodynamic Design Optimization of Wind Turbine Rotor Blades", World Academy of Science, Engineering and Technology 60, 2009.

[9] Migliore, "The Potential for Reducing Blade-Tip Acoustic Emissions For Small Wind Turbines", NREL/SR-500-43472, February 2009.

[10] Tim Fischer ", Mitigation of Aerodynamic and Hydrodynamic Induced Loads of Offshore Wind Turbines", 5th Ph.D seminar on wind energy in Europe, Durham University, European Academy of Wind Energy(EAWE), 30th September and 1st October-2009.

[11] Barlas and Van Kuik, "State of the Art and Prospectives of Smart Rotor Control for Wind Turbines", A Journal Progress in Aerospace Sciences, Volume 46, Issue 1, PP 1–27, January 2010.

[12] Devenport. et al, "Aeroacoustic Testing of Wind Turbine Airfoils", NREL/SR-500-43471, May 2010.

[13] Nitin Tenguria, "Aerodynamic Design of a HAWT Blade for Indian Wind Condition", International Journal of Advances in Engineering, Science and Technology (IJAEST), ISSN: 2249-913X, Vol. 1 No. 1 November 2011.

[14] S. Lain. et al, "Aerodynamic and Structural Evaluation of Horizontal Axis Wind Turbines with Rated Power over 1 MW".

[15] Juan Mendez and David Greiner, "Wind blade chord and twist angle optimization by using genetic algorithms".

[16] Donny. et al, "Evaluation of Airfoils for Small Wind Turbines", WTAMU / Alternative Energy Institute In cooperation with USDAAgricultural Research Service.

[17] Turgut Gursel. et al, "Analysis Of Rotor Blades Of A Farm WindPower Plant",

[18] Ajao & Adegun, "Evaluation Of The Rotor Aerodynamics Of A Wind Turbine Using Combined Blade Element And Momentum Theory"

[19] Vermeer. et al, "Wind Turbine Wake Aerodynamics"

[20] Dr. Vendan. et al, "Analysis of a Wind Turbine Blade Profile for

Tapping Wind Power at the Regions of Low Wind Speed"

[21] Franck Bertagnolio. et al, "Wind Turbine Airfoil Catalogue"

[22] Richard . et al, "Aero-Structural Performance of Multiplane Wind Turbine Blades"

[23] Rahman, M..R., Huque, M. M., Islam, M.N. and Hasan, M., 2009. Mechanical Properties of Polypropylene Composite Reinforced with Chemically Treated Abaca, J. Composites, 40, p.511.

[24] Soom. M., R., Aziz, A. A., Hassan, W. H, and Top, M. A.G., 2009. Solid-State Characteristics of Microcrystalline Cellulose from Oil Palm Empty Fruit Bunch Fiber, J. Oil Palm Research, 21, p.613.

[25] Sulaiman, F. F., Abdullah, N., Gerhauser, H., and Shariff, A., 2011. An Outlook of Malaysian Energy, Oil Palm Industry and Its Utilization of Wastes as Useful Resources, J. Biomass and Bioenergy, 35, p.3775.

[26] Jawaid, M., Khalid, A.H.P.S., and Abubakar, A., 2010. Mechanical Performance of Oil Palm Empty Fruit Bunches/ Jute Fibers Reinforced EpoxyHybrid Composites, J. Material Science and Engineering, 527, p.7944.

[27] Rozman, H.D., Tay, S., Abubakar, A., and Kumar, R.N., 2001. Tensile Properties of Oil Palm Empty Fruit Bunch- Polyurethane Composite, J. Polymer European, 37,p.1759.

[28] Rozman, H.D., Tay, G.S., Abubakar, A., Kumar, R.N., Abusamah, A., Ismail, H., and Ishak, Z.A.M., 2001. Polypropylene- Oil Palm Empty Fruit Bunch-Glass Fiber Hybrid Composite: A Premilinary Study on The Flexural and Tensile Properties, J. European Polymer Journal, 37, p.1283

[29] Ahmad M A A, Majid M S A, Ridzuan M J M, Firdaus A Z A and Amin N A M 2017 Tensile properties of interwoven hemp/PET (Polyethylene Terephthalate) epoxy hybrid composites, *Journal of Physics: Conf. Series*. **908,** 012011 doi :10.1088/1742-6596/908/1/012011.