Design and Structural Analysis Using FEM of Highway Composite Helical Wind Turbine

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DESIGN AND STRUCTURAL ANALYSIS USING FEM OF HIGHWAY COMPOSITE HELICAL WIND TURBINE

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ABSTRACT

Energy is a significant angle in our consistent life. The assets we use are restricted whereas the populace devouring the equivalent is expanding step by step. Nowadays the prerequisite of power is a lot higher than its age, thus the fundamental target of our work is to create power at minimal expense with no impact on climate. The target of the work is to plan a Vertical breeze turbine to recover wind energy from vehicles on the parkway. A lot of wind energy is delivered because of the pressing factor contrast made by the moving vehicles on the roadways. This breeze energy can be used for the age of electrical energy with the assistance of vertical hub wind turbines. The point of the undertaking is to plan the helical breeze turbine utilizing two materials Al 6061, GFRP, and CFRP materials with different thicknesses of the turbine blade **4mm and 6mm** play out the static and Modal analysis investigation at last discover the stress, shear stress, total distortion in static examination and modal analysis at various frequencies at modal investigation Vertical pivot wind turbine can be introduced on the middle of the streets so the breeze from the two sides of the middle will act extraneously inverse way on the two sides of the turbine in this way speeding up following up on the turbine. The breeze power outfit through this strategy can be utilized for road lighting, traffic light lighting, cost doors, and so forth.

Keywords: Vertical Wind turbine, Blades, Materials-CFRP, GFRP, AL6061, Design, FEM.

1. INTRODUCTION:

A windmill is a mill that converts wind energy into rotational electricity (mechanical energy) via vanes called sailor edges. Windmills were traditionally used to process grain, siphon water, or both hundreds of years ago. As a result, they were frequently gristmills, wind siphons, or both. The majority of modern windmills appear as windmills used to provide strength or wind siphons used to siphon water, either for land waste or to cast off groundwater. A wind turbine is a machine that converts the wind's dynamic energy into electrical pressure. The term appears to have shifted from equal hydroelectric generation to equal hydroelectric generation (rotary propeller). An airfoil-powered generator is a specialized representation for this type of device.

Figure 1. air foil powered

Figure 2. The wind turbine rotates

1.2. FEATURES OF WIND TURBINE:

•The turbine is self-beginning.
•They are Omni-directional and don't need pointing toward the wind.
•The lower sharp-edge rotational rates infer lower clamor levels.
•Perceived as being all the more tastefully satisfying.

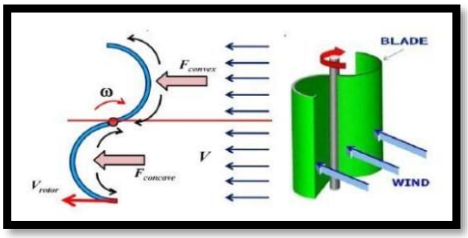


Figure 3. Drag force acting on the wind turbine

2. LITERATURE REVIEW:

[1] According to SAHA et al. (2019), of the United Kingdom, because of their low rotational speed and low power output, SAVONIUS rotors lag behind horizontal axis wind turbines in terms of technology. The varying voltage from the rectifier will then be regulated by a converter to produce a steady DC voltage. His impressive intellect and insightfulness played a significant role in the success of our research. However, it is believed that with some design and blade modification, the SAVONIUS types of machines could be quite useful for small-scale power requirements. Preliminary research in this area resulted in the creation of a new blade shape with a twist for the SAVONIUS rotor span. When compared to the conventional blade, the twisted blade made of sheet metal has demonstrated its potential.

[2] According to S. RAUTA et al (2021), the rotor assembly is made up of a cylindrical solid mild steel shaft wind power and its potential that can be harnessed in the future to meet current energy demand. This report also demonstrated the integration of wind farms with the transmission grid, as well as the problems associated with it and the potential solutions that can be used to solve them and improve performance.

[3] P N SANKAR et al (2018), One advantage of this configuration is the ability to locate generators and gearboxes close to the ground, making these components easier to service and repair. According to CHONGYANG ZHAO, a surface-mounted permanent magnet synchronous generator with concentrated windings is designed. The air gap flux density and induced voltage have low harmonic contents in the design. "Wind Energy Utilization Coefficient Characteristics
Experiment Validation of Vertical Axis Wind Turbine Control System"

[4] ARAVIND, RAJPARTHIBAN, and RAJPRASAD state that wind the power generation system experimental platform is established and wind generator external characteristics are measured. Wind energy utilization coefficient characteristics are in good agreement with wind energy utilization coefficient characteristic theory.

[5] WT. MADANI, COSIC, SADARANGANI, states that A combined type straight-bladed vertical axis wind turbine (CT -SBV A WT) was designed in this study by setting a SAVONIUS rotor having good starting performance into the SB-VA WT SAVONIUS rotor set in the SB-V A
WT can greatly improve the starting performance of the SB-VA "A Permanent Magnet Synchronous Generator for a Small-Scale Vertical Axis Wind Turbine".

[6] YAN LI, FANG FENG, states that power generated is directly proportional to the wind speed available. Design of the vertical turbine due to its advantage of operating at a low wind speed over that of the horizontal turbine. "Computer Simulation on the Performance of a Combined-type Vertical Axis wind Turbine",

[7] CHONGYANG ZHAO, JUN LUO, states that Wind generator external characteristics are measured. Speed ratio and wind turbine characteristics are analyzed. “Experiment Validation of
Vertical Axis Wind Turbine Control System based on Wind Energy Utilization Coefficient Characteristics,"

3. PROJECT OVERVIEW:

Helical wind turbine. This exam became supposed to analyze the number one examination of helical wind turbines for diverse materials. The examination researches 1. The Vertical wind turbine SAVIOR type – the remarkably appropriate material for the Helical wind turbine development through manner of analyzing the strain, distortion, and shear stress created because of stacking conditions and finding out the frequencies in modular research because of the disfigurement.2. To model the helical wind turbine blades with numerous thickness four and 6mm in utilizing CATIA programming and exam utilizing the ANSYS 16.2.

3. To perform an underlying exam for inspecting the stress, pressure, overall deformation, and natural frequencies created in shape at configuration load situations.
4. To decide the static and modal examination for noticing the scope of recurrence created inside the layout utilizing modular research.
5. To decrease the heaviness of the layout using advancement degree utilizing numerous materials.
6. Finally completed the suitable substances of the helical wind turbine in those materials AL 6061, GFRP, AND CFRP the usage of various thicknesses 4mm and 6mm compared to those substances.

3.2. METHODOLOGY:

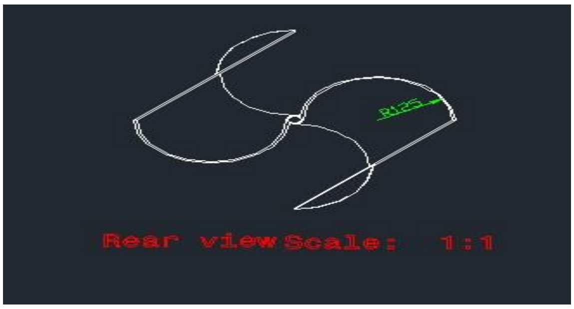
The examination of Vertical wind turbines will be accomplished for various materials. The upward wind turbine with various materials using different thicknesses of blades 4mm and 6mm will be tried by applying power during the upward wind turbine primary examination in ANSYS 16.2. Then, at that point, the complete twisting, Von-misses stress, strain, total deformation, and natural frequencies were determined for various compounds subsequent to applying the limit conditions.

3.3. PROBLEM IDENTIFICATION:

AL 6061 considerable strain and successful Failure. In this challenge, high electricity cloth on this task picks the CFRP and GFRP substances analyzed all substances at lengthy ultimate finished up the affordable substances due to the CFRP is the much less pressure, Deformation, shear stresses. From the writing, it's miles visible that a big degree of examination work has been directed inside the area of the touchdown vertical wind turbine. It has been installed that there may be a need to beat problems related to clashing prerequisites like energy and solidness of wind turbine, and concurrently geared up to face up to the burdening impact of the helical wind turbine and avoid the number one damage while pivoting quickly. Scientists have proposed reasonable substances.

3.4. DIMENSIONS OF THE VAWT:

- DIMENSION DIAMETER (D) = 0.5 m
- HEIGHT (H) = 1 m
- THICKNESS (T) = **4mm & 6mm**
- SWEPT AREA (A) = D * H = 0.5 * 1 = 0.5 m^2



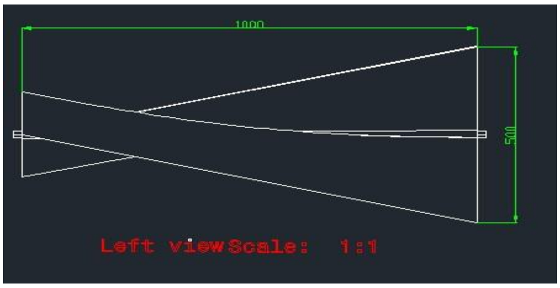


Figure 4. Right view Dimension *Figure 5. Left view*

Dimension

4. DESIGN PROCEDURE IN CATIA WORKBENCH:

Go to the sketcher workbench and create the circle as per the dimensions as specifications. After creating the plane in another plane again go to the wireframe and surface design and apply the sweep option as per the dimensions again go to the part design workbench create the shaft and generator as per the specification as shown below figur

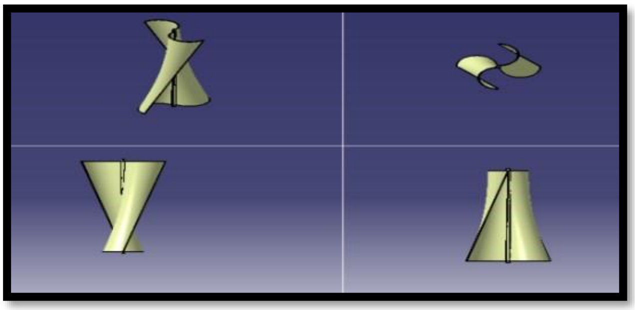


Figure 6. multiple views in the CATIA work bench

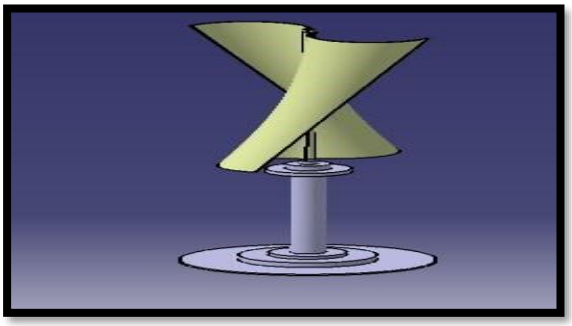


Figure 7. Isometric view of vertical helical wind turbine blade

5. PROCEDURES OF STATIC ANALYSIS & MODAL ANALYSIS:

Create the geometry in CATIA workbench and store the file in its format and open ANSYS workbench apply engineering information (cloth residences), create or import the geometry, following version(meshing), practice boundary conditions(setup) shown the effects (strain, deformation, Shear pressure).

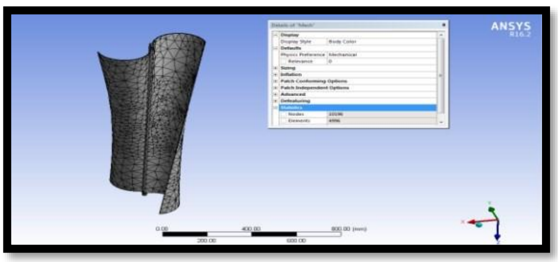


Figure 8. Mesh

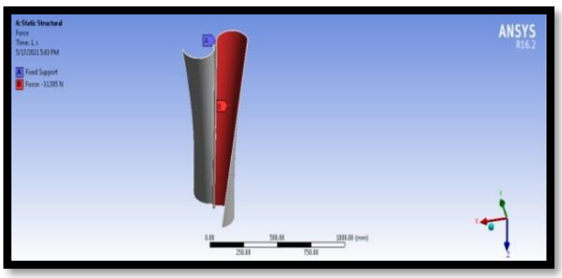


Figure 9. Boundary conditions

6. RESULTS AND DISCUSSIONS:

In this venture, the Vertical wind turbine is investigated Static and Modal exam methods with the accompanying substances Al6061 and CFRP to discover the excellent fabric. The working pressure carried out to the deliberate helical vertical wind turbine in every one of the instances is 31.585N this is really worth being brought from the Vertical wind turbine. The arrangement stage manages the arrangement of the problem in line with the problem definitions. All the drawn-out paintings of defining and collecting lattices are completed by means of the PC finally distortions, stress, and shear stress esteems are discovered as displayed under figures.

6.1 (4 mm) THICKNESS OF HELICAL WIND TURBINE:

6.1.1. STATIC ANALYSIS AL6061 MATERIAL:

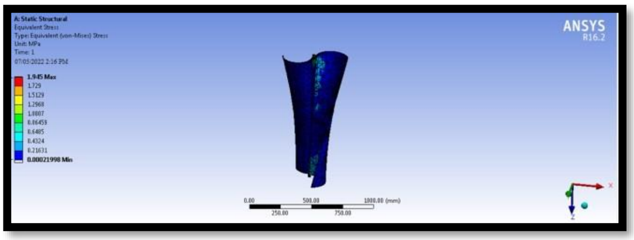


FIGURE 10.VON-MISSESSTRESSOFAL6061

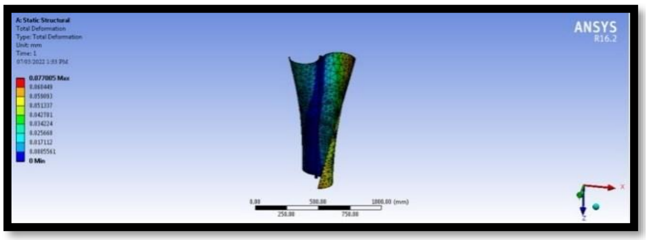


FIGURE 11. TOTAL DEFORMATION OF AL 6061

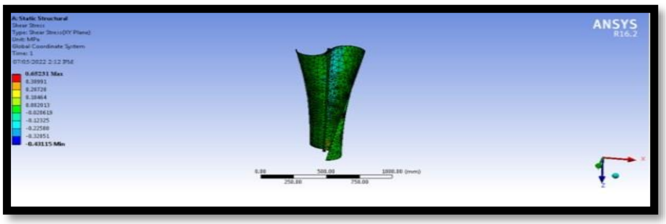


Figure 12. Shear stress of Al 6061

6.1.2. STATIC ANALYSIS OF CFRP MATERIAL:

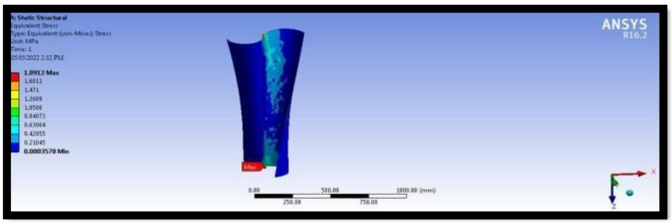


Figure 13. Von-misses stress of CFRP

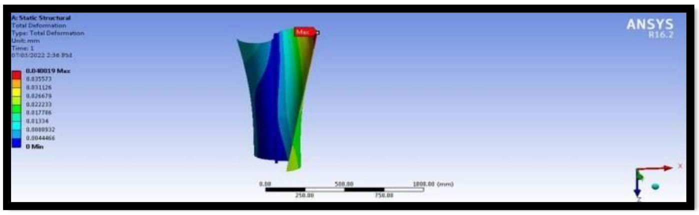


Figure 14. Total Deformation of CFRP

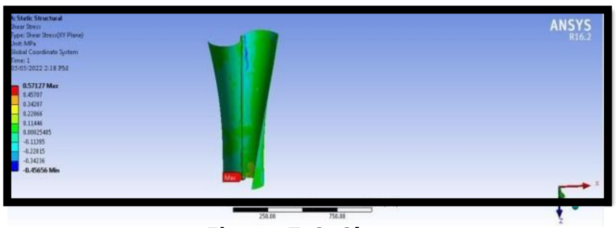


Figure 7.6: Shear stress

Figure 15. Shear stress

6.1.3. STATIC ANALYSIS GFRP MATERIAL:

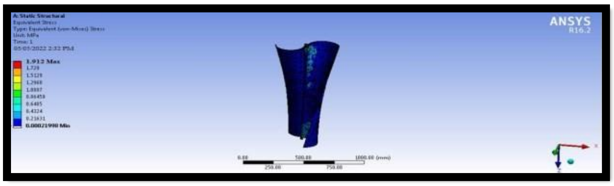


Figure 16. Von-misses stress of GFRP

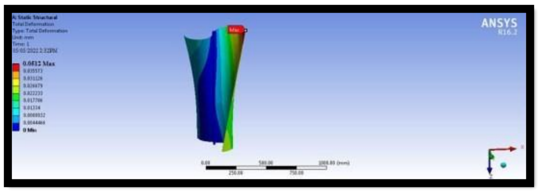


Figure 17. Total Deformation of GFRP

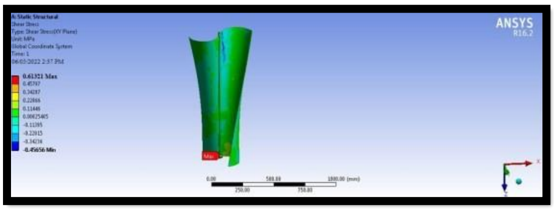


Figure 18. Shear stress graph of GFRP Material

6.2 (6 mm) THICKNESS OF HELICAL WIND TURBINE BLADE:

6.2.1. STATIC ANALYSIS OF AL6061 MATERIAL:

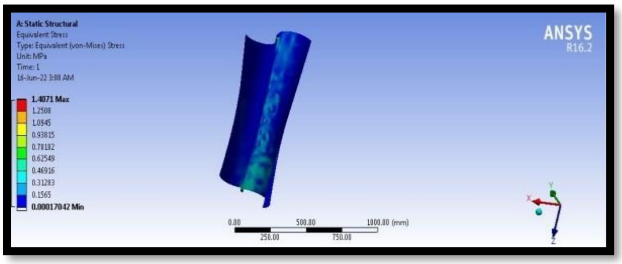


Figure 19. Von-misses stress of AL 6061 Material

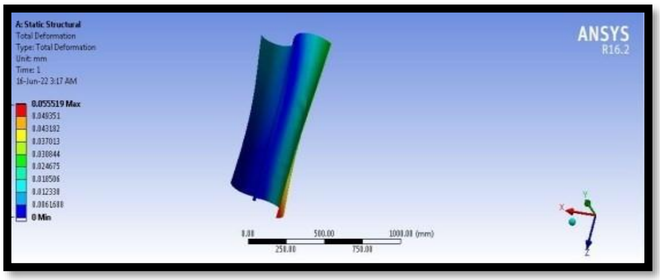


Figure 20. Total deformation of AL 6061 Material

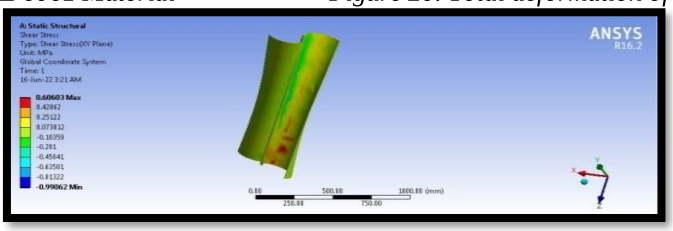
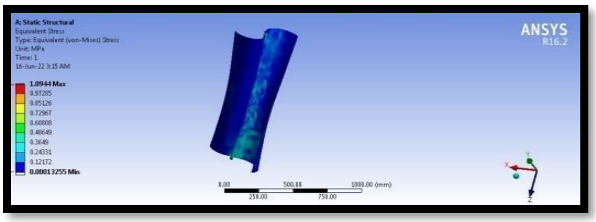


Figure21. Shear stress of AL6061 Material

6.2.2. STATIC ANALYSIS OF CFRP MATERIAL:



22.Von-misses stress of CFRP Material

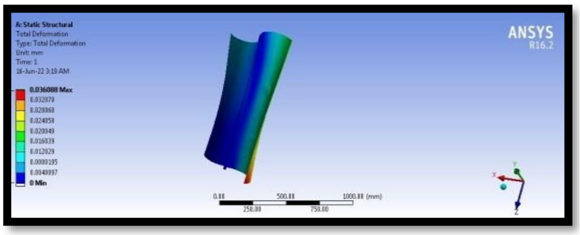


Figure 23. Total deformation of CFRP Material

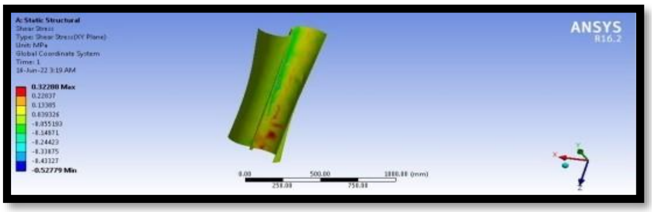


Figure 24. Shear stress of CFRP Material

6.2.3. STATIC ANALYSIS OF GFRP MATERIAL:

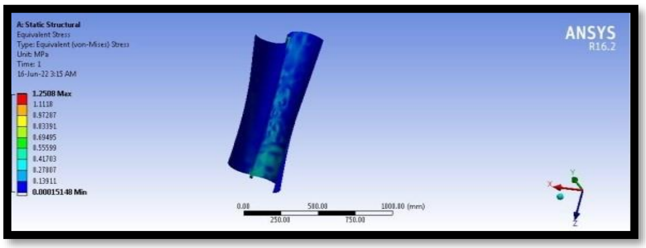


Figure 25. Von-misses stress of GFRP Material

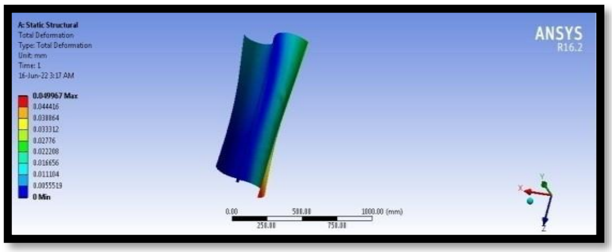


Figure 26. Total deformation of GFRP Material

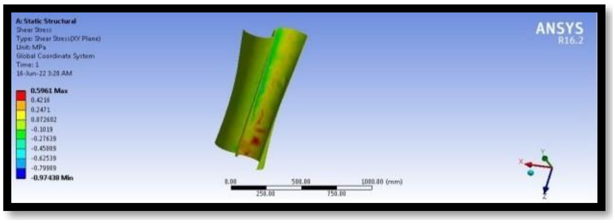


Figure 27. Shear stress of GFRP Material

6.3. MODAL ANALYSIS OF CFRP MATERIAL:

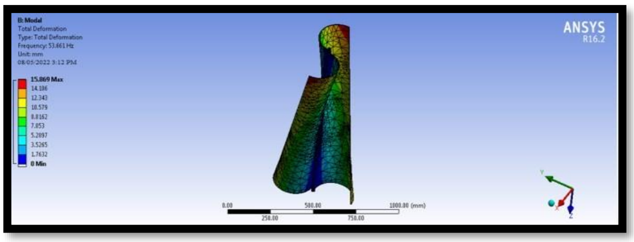


Figure 28. Mode 1 total deformation of CFRP

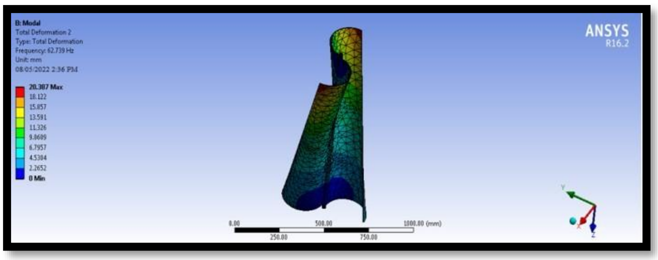


Figure 29. Mode 2 total deformation of CFRP

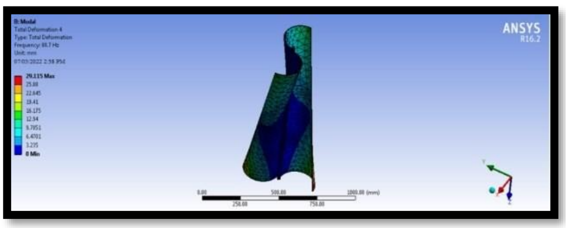
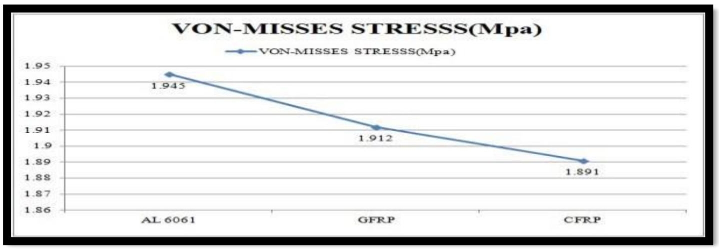


Figure 30. Mode 3 total deformation of CFRP

6.4. VON-MISSES STRESS GRAPH:

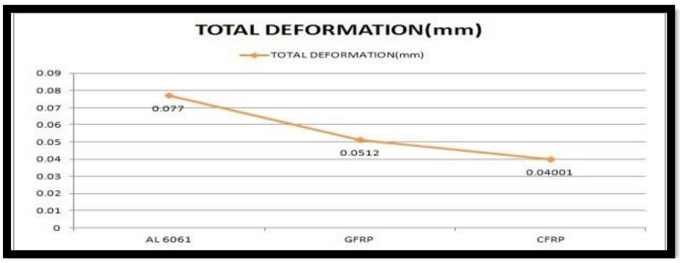
The below graph indicates that Helical wind turbine blade thickness of 4mm Observed the Vonmisses stresses the usage of numerous substances CFRP, GFRP, AL6061. Finally determined the CFRP cloth have less von-misses strain (1.891 MPa) and maximum von-misses stress of Helical highway wind turbine blade are AL 6061 1.945 MPa shown beneath graphs.



Graph 1. Von-misses stress graph between numerous substances

6.5. TOTAL DEFORMATION GRAPH:

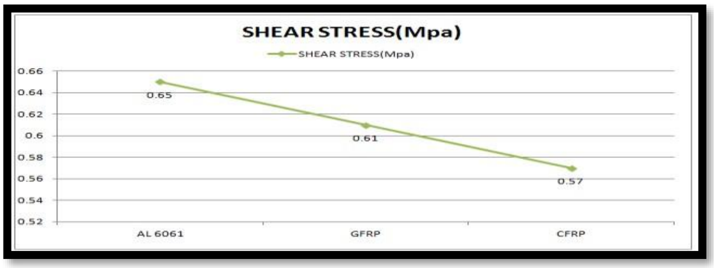
The beneath graph suggests that Helical wind turbine blade thickness of 4mm Observed the Total deformation the use of numerous substances CFRP, GFRP, AL6061. Finally positioned the CFRP fabric have much less Total deformation (0.04001mm) and maximum Total deformation of Helical toll road wind turbine blade are AL 6061 (0.077mm) verified beneath graphs.



Graph 2. Total deformation graph between various substances

6.6. SHEAR STRESS GRAPH:

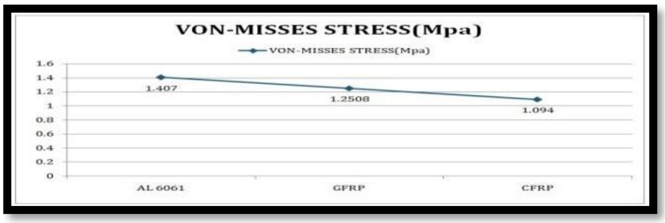
The below graph shows that Helical wind turbine blade thickness of 4mm Observed the shear stresses graph using various materials CFRP, GFRP, AL6061. Finally observed the CFRP material have less shear stress (0.57Mpa) and highest shear stress of Helical highway wind turbine blade are AL6061 (0.65Mpa) shown below graphs.



Graph 3. Shear stress graph between various materials

6.7. VON-MISSES STRESS GRAPH:

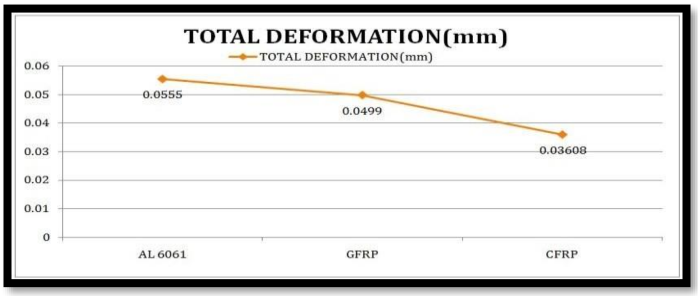
The under graph shows that Helical wind turbine blade thickness of 6mm Observed the Vonmisses stresses the use of various substances CFRP, GFRP, AL6061. Finally observed the CFRP fabric has a much fewer von-misses strain (1.094MPa) and the maximum von-misses strain of the Helical dual carriageway wind turbine blade is AL 6061 1.407MPa proven beneath graphs.



Graph 4: Von-misses stress graph between various materials

6.8. TOTAL DEFORMATION GRAPH:

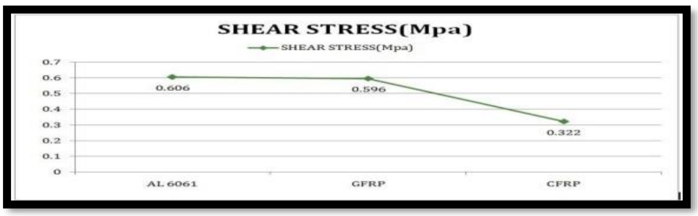
The under graph indicates that Helical wind turbine blade thickness of 6mm Observed the Total deformation the use of various substances CFRP, GFRP, AL6061. Finally located the CFRP cloth have much less Total deformation (0.03608mm) and highest Total deformation of Helical toll Road wind turbine blade are AL6061 (0.0555mm) shown under graphs.



Graph 5: Von-misses stress graph between various materials

6.9. SHEAR STRESS GRAPH:

The below graph shows that the Helical wind turbine blade thickness of 6mm Observed the shear stresses graph the usage of diverse substances CFRP, GFRP, AL6061.Finally found the CFRP material have less shear stress (0.322Mpa) and highest shear stress of Helical highway wind turbine blade are AL 6061 (0.606Mpa) shown below graphs.



Graph 6: Shear stress graph between various materials

7. CONCLUSION

Modelling and simulation of helical vertical turbine has executed the usage of CATIA software program. After watching the static analysis values, we can conclude that CFRP at 6mm thickness blade have better strain bearing capability in comparison with the opposite cloth al6061 and GFRP it showing better power values while loads are applied. An enormous amount of wind strength is produced due to the stress difference created by way of the moving motors on the highways. This wind energy can be applied for the era of electrical electricity with the help of vertical axis wind mills. The goal of the project is design the helical wind turbine the usage of with materials Al 6061, GFRP and CFRP substances perform the static and modal analysis ultimately find out the strain, shear strain, general deformation in static analysis and deformations at specific frequencies at modal evaluation Vertical axis wind turbine can be hooked up on the median of the roads so that the wind from each aspects of the median will act tangentially in an opposite course on each sides of the turbine thereby increasing powerful wind speed acting on the turbine. The wind energy harnessed thru this method may be used for avenue lighting, visitors sign lighting, toll gates and so forth. On doing static evaluation of a vertical wind turbine, it is clear that, the most Stress, shear strain and deformations are triggered. If we examine stress, corresponding deformations of the fabric composites (CFRP,) with 6mm above end result in the end CFRP is concluded as appropriate material.

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