ISSN NO. 2320-5407

Journal Homepage: - www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/2476

DOI URL: http://dx.doi.org/10.21474/IJAR01/2476

RESEARCH ARTICLE

LINEAR STATIC ANALYSIS OF WIND TURBINE BLADE USING FE MODELLING.

Santhosh. A., Manjunatha Babu. N. S and Mohan Kumar. K

Department of Mechanical EngineeringDr.T.Thimmaiah Institute of Technology, KGF.563120, India.

……………………………………………………………………………………………………....

Manuscript Info

……………………..

Manuscript History

Received: 23 October 2016
Final Accepted: 21 November 2016
Published: December 2016

Key words:-
Wind Turbine Blade, Linear Static Analysis, FEM.

Abstract

………………………………………………………………

The requirements for improved stiffness, reliability, fatigue life and increased efficiency involves challenges of developing innovative design solutions. The present work mainly focus on the design of wind turbine blade where the analytical and FEM analysis approach was implemented to analyze baseline design. Initially static analysis was performed to obtain total deformation, strain and the stress of wind turbine blade. Three Dimensional model was created using CATIA and FE software ANSYS was used for discretization and analysis to obtain expected solution. The results were obtained through linear static analysis in terms of Total deformation while Minimum principal stress, Max Principal stress were found to be nearly equal for both CFRP and Aluminium alloy model. Finally on comparing the results of CFRP with AL it was observed that the overall weight of the wind turbine blade was optimized.

……………………………………………………………………………………………………....

Introduction:-

CFRPs are expense to produce but are generally utilized wherever high strength to-weight proportion and rigidness are required, such as automotive, civil engineering, sports products, aerospace and an maximizing number of other customers and technological applications. In this instance the composite classifies two sections: a matrix and reinforcement. In CFRP the reinforcement is carbon fiber, which gives the strength. The matrix is generally a polymer resin, for example, epoxy to bond the reinforcement together. Since CFRP contains of two distinct components, the material properties depend upon these two components.

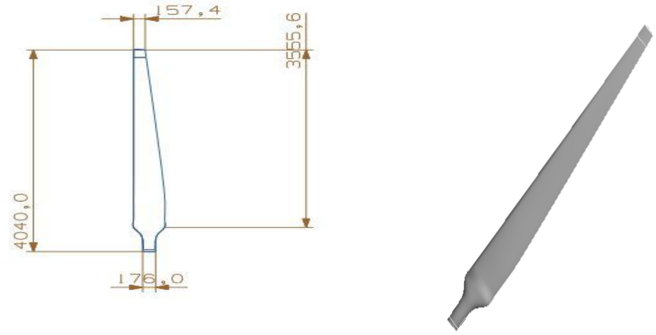
Composites have been the material chosen for wind turbine blade development for few decades, partially because of their better fatigue performance when comparing with different materials. In many design processes, structural segments are embedded utilizing adhesive bond lines. Entirely these materials are influenced in some way by fatigue loads.

Linear static analysis, when the masses are applied to a body, the body gets deformed and the impact of masses is transmitted throughout the body. The external masses initiate internal powers and responses to render the body into a condition of equilibrium. It calculates stresses, strains, displacement, and reaction forces under the outcome of applied masses.

Corresponding Author: -Santhosh. A.
Address: -Department of Mechanical Engineering,Dr.T.Thimmaiah Institute of Technology, KGF.563120, India.

Geometry Modelling of Wind Turbine Blade:-

The present work was carried out on the analysis of the wind turbine blade and structural optimization of the turbine blade. This work mainly focus on Finite Element Analysis and weight reduction of wind turbine blade. The work involves the geometrical modelling of the wind turbine blade and later blade was meshed using ANSYS and was analyzed for different load conditions. The same model was later on reinforced into the matrix which forms the turbine blade composite. The results from the FE analysis are comparing with two different materials i.e., CFRP and Aluminium. The parameters like stress, deformation, strain are obtained for different load conditions.



(a) **(b)**

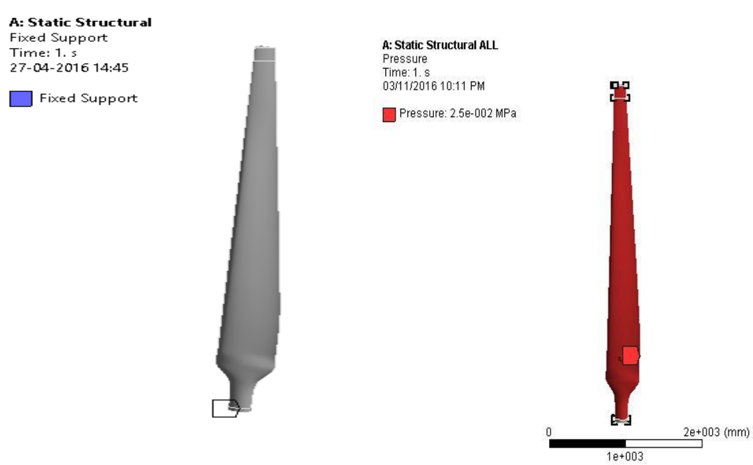
Figure 1:- (a)Geometry of Wind Turbine Blade (b) 3D Model of Wind Turbin Blade

FE Analysis:-

The required model created in catia was imported to Ansys 14.5 analysis software and the required material properties, boundary conditions are fixed and Hexa dominant element was used for the element type. After the pre-processor work solution is obtained by the application of desired load for both the materials of CFRP and Aluminium Alloy. The post processing work of obtained results are analyzed and compared.

Result and Discussion:-

Linear Static Analysis of Wind Turbine Blade:-

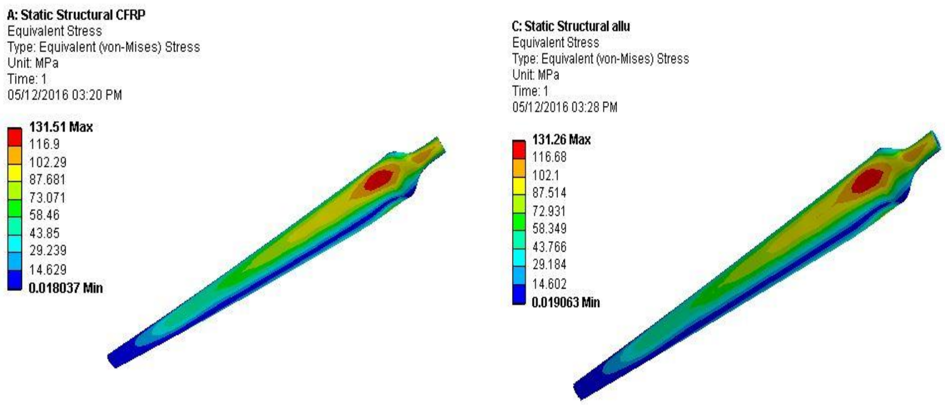


(a) (b)

Figure2:- (a) Fixing one end of Turbine Blade (b) Pressure applied to turbine blade.

A linear static analysis was carried out after fixing the one end of the wind turbine blade. Based on the boundary condition the analysis was done and optimization was carried out. Here in order to analyze weight optimization results of two different materials is considered. Based on these stress results optimization was done. The model which is optimized should perform its function and meet all the requirements like stress level and keep the total weight to minimum. The von mises stress calculated which was less than yield strength of the CFRP material was compared with Aluminium. The weight reduction of the wind turbine blade was obtained by stress optimization. The maximum stress obtained for CFRP and AL were compared. As a result weight of CFRP wind turbine blade was reduced and could be replaced easily if the problem persist.

Fe Analysis for Equivalent Stress of Wind Turbine Blade:-

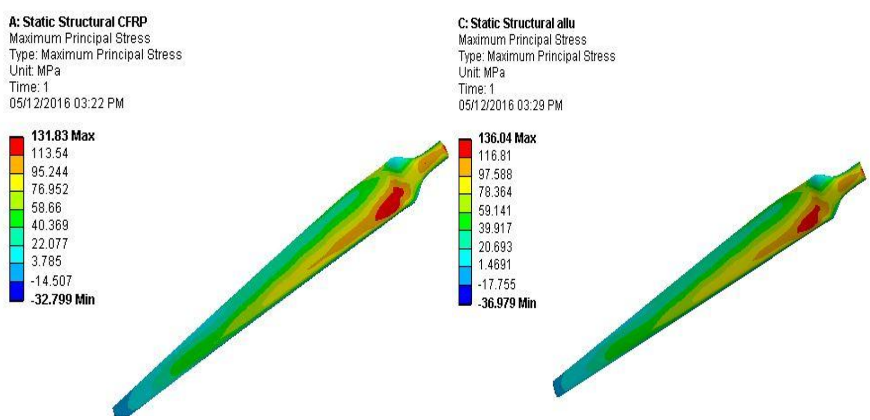


(a) (b)

Figure 3:- (a) Equivalent stress of CFRP (b) Equivalent stress of Aluminium Alloy.

The finite element simulation of wind turbine blade shows the various stress contours like normal stress, principal stress, shear stress and stress intensity contours, among which Von Mises stresses, maximum and minimum principal stress and total deformations over the wind turbine blade was obtained. From fig 3(a) and 3(b) the maximum von mises stresses was observed to be 131.51Mpa and 131.26 Mpa in case of AL and CFRP respectively and also the average distribution of stress were observed for failure cases.

Fe Analysis for Max Principle Stresses of Wind Turbine Blade:-

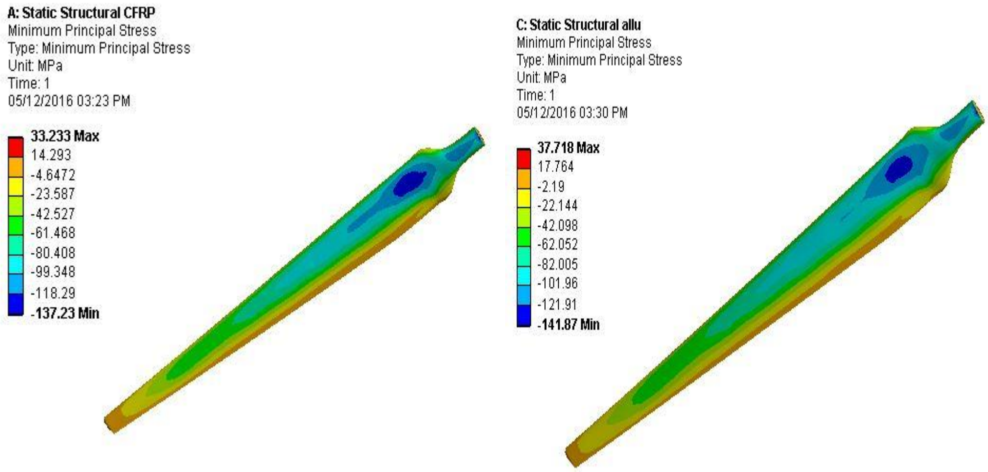


(a) (b)

Figure 4:- (a) Max principle stress of CFRP (b) Max principle stress of Aluminium Alloy.

The finite element simulation of wind turbine blade was carried out and from fig 4(a) and 4(b) the maximum principal stresses was observed to be 131.83Mpa and 136.04 Mpa in case of CFRP and AL respectively and also the average distribution of stress were observed for failure cases

Fe Analysis for Min Principle Stress of Wind Turbine Blade:-

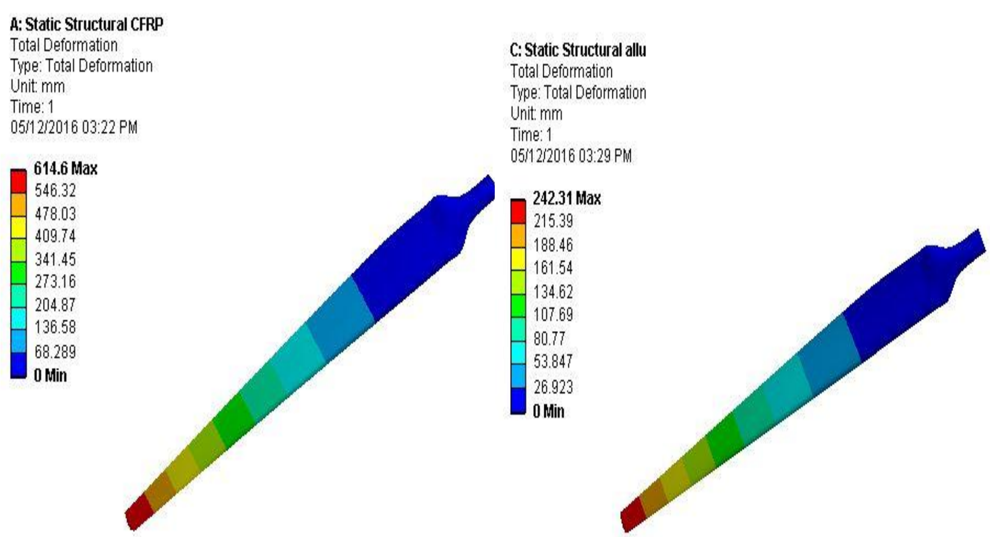


(a) (b)

Figure 5:- (a) Minimum Principal stress of CFRP (b) Minimum principal stress of Aluminium Alloy.

The finite element simulation of wind turbine blade was carried out and from fig 5(a) and 5(b) the minimum principal stresses was observed to be 33.233 and 37.718 Mpa in case of CFRP and AL respectively and also the average distribution of stress were observed for failure cases.

Fe Analysis for Total Deformation of Wind Turbine Blade:-

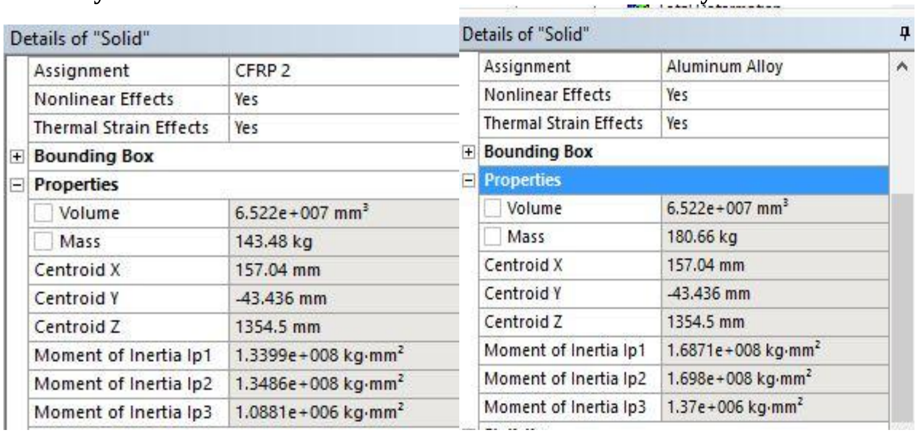


(a) (b)

Figure 6:- Total Deformation of CFRP (b) Total Deformation of Aluminium Alloy.

The finite element simulation of wind turbine blade was carried out and the total deformations was observed to be 614.4mm and 242.31mm in case of CFRP and AL as shown in fig 6(a) and 6(b).

Fe Analysis Results for Masses of CFRP and Aluminium Alloy:-



(a) (b)

Figure 7:- (a) Shows mass of CFRP (b) shows mass of Aluminium Alloy.

From figure 7(a) and 7(b) it was observed that the weight obtained for CFRP was less when compared with that of Aluminium alloy.

Table 1:- Comparision of Linear Static Analysis Results between CFRP and Aluminium Alloy.

	CFRP	AL
Equivalent stress(von-mises)	131.51mpa	131.56mpa
Max principal stress	131.83 mpa	136.04 mpa
Min principal stress	32.233 mpa	37.718 mpa
Total deformation	614.6 mm	242.31 mm
Mass	143.48kg	180.66kg
Reduction in Weight	37.18Kg (20.58%)	

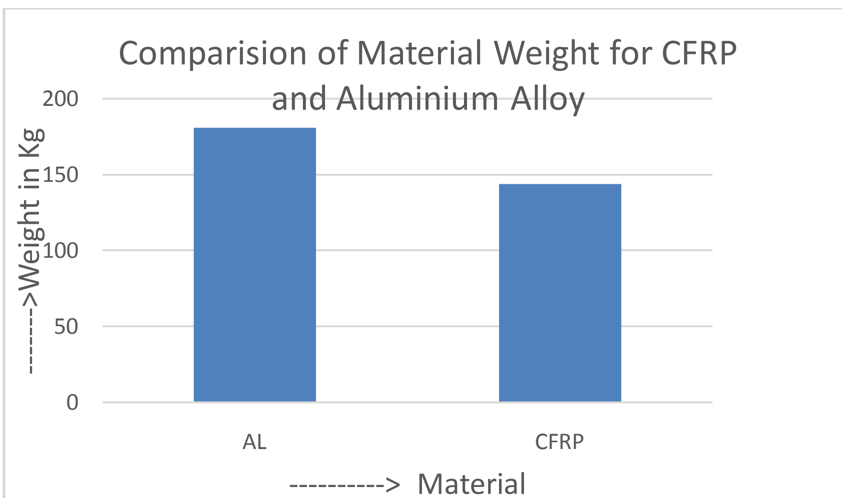


Figure 8:-Comparision of Material Weight of CFRP and Aluminium Alloy.

Conclusion:-

The linear static analysis work on CFRP and Aluminium Alloy of Wind turbine blade using FE Ansys software is carried out successfully. In this study weight optimization using FEA was been made and reduction in weight through material optimization which are in safe for different materials i.e. for CFRP and Aluminium Alloy. Design and linear static analysis carried out to find the maximum equivalent stress which is 131.51MPa was found less than yield stress for a CFRP which is 210MPa.It was observed that reduction in 20.58% of material compared to Aluminium Alloy can be saved. Hence design of CFRP wind turbine blade was proved to be good compared to Aluminium Alloy.

Reference:-

1. Static and Fatigue Analysis of Wind Turbine Blades Subject to Cold Weather Conditions Using Finite Element Analysis by Patricio Andres Lillo Gallardo B.Sc., Catholic University of Chile, 1999 M.Sc., Catholic University of Chile, 2001
2. Linear Static Analysis and Computational Validation of a Composite Wind Turbine Blade by Jayaram.V1, Rony Mathew, Praveen Joseph Johnson, Joel Joe Antony, Jerin Thomas2, Thiruvananthapuram, Kerala, India1
3. Hau, E. Wind Turbines, Fundamentals, Technologies, Application, Economics, 2nd ed.; Springer:Berlin, Germany, 2006.
4. Analysis of wind turbine blades from lignocellulosic composites subjected to static bending by transilvania university of brasov, faculty of mechanical engineering b-duleroilor, nr 29, brasov, Romania.
5. Shokrieh MM, Rafiee R. Static analysis of fatigue phenomenon in a HAWT composite blade.
6. Gasch, R.; Twele, J. Wind Power Plants; Solar praxis: Berlin, Germany, 2002.
7. Burton, T. Wind Energy Handbook; John Wiley & Sons Ltd.: Chichester, UK, 2011.
8. Fuglsang, P.; Madsen, H.A. Optimization method for wind turbine rotors. J. Wind Eng. Ind. Aerodyn. 1999, 80, 191–206.
9. Sutherland HJ. On the fatigue analysis of wind turbines. Sandia National Laboratories, Albuquerque, New Mexico, June 1999, SAND99-0089.
10. L. R. McKittrick, D. S. Cairns, and J. Mandell, "Analysis of a composite blade design for the aoc 15/50 wind turbine using a finite element model," tech. rep., Sandia National Laboratories, SAND2001-1441, 2001.
11. Mandel JF, Samborsky DD, Cairns DS. Fatigue of composite materials and substructures for wind turbine blades.
12. Shokrieh MM, Rafiee R. Extraction of required mechanical properties for FEM analysis of multidirectionalcomposites using CLT approach.
13. Tsai SW, Thomas Hahn H. Introduction to composite materials. USA: Technomic Publishing Co; 1980.
14. Gupta, R.S. and Rao, S.S. (1978). Finite element eigenvalue analysis of tapered and twisted Timoshenko beams. Journal of Sound and Vibration 56(2), pp 187-200.
15. Perkins, F.W. and Cromack, D.E. (1978). Wind Turbine Blade Stress Analysis and Natural Frequencies. Wind Energy Center Reports, Paper- 11.
16. Amer C, Sahin M (2014) Structural Analysis of a Composite Wind Turbine Blade. World Academy of Science, Engineering and Technology, International Journal of Mechanical, Aerospace, Industrial and Mechatronics Engineering Vol: 8(7)
17. Jureczko M, Pawlak M, Mezyk A (2005) Optimization of wind turbine blades, Journal of Materials Processing Technology 167:463 – 471.
18. Yang, J.S.; Peng, C.Y.; Xiao, J.Y.; Zeng, J.C.; Xing, S.L.; Jin, J.T.; Deng, H. Structural investigation of composite wind turbine blade considering structural collapse in full-scale static tests. Compos. Struct. 2013, 97, 15–29.
19. Xiao Chen, Wei Zhao, Xiao Lu Zhao and JianZhongXu ―Failure Test and Finite Element Simulation of a Large Wind Turbine Composite Blade under Static Loading‖- Energies 2014, 7, Pg: 2274-2297.
20. M. W. Hyer, Stress Analysis of Fiber-Reinforced Composite Materials. WCB McGraw-Hill, 1998. 5, 29, 30, 31, 53.