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Design and Structural Analysis of Horizontal Axis Wind Turbine Blade

N.Tamiloli1, Kurapati Lokesh kumar1, Mudra boyina venkateswarlu1, Kanulla Karthik2
1. Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur District,Andhra Pradesh, India,

Article Info
Volume 83
Page Number: 9493 – 9500
Publication Issue:
May - June 2020

Article History
Article Received: *19 November 2019*
Revised: *27 January 2020*
Accepted: *24 February 2020*
Publication: *18 May 2020*

Abstract:
The objective of this project is to design the blade of a horizontal axis wind turbine. This work includes the advancement of drag and lift design concepts. This work uses ANSYS workbench to explore the study of a horizontal axis wind turbine blade Concepts. The blade is examined in this work for four different blade materials Aluminium, stainless steel, Structural steeland Titanium. The purpose of the study is to validate blade strength and to analyse with taken materials in order to take the best material for the blade of the horizontal axis wind turbine and to obtain the blades necessary properties.
Keywords: *Blade design, Solid works, Ansys Workbench, Structural Analysis.*

I. INTRODUCTION

Turbine is a tool that converts rotational energy from a fluid that is consumed in usable work or energy by a rotor device. A turbine with a shaft mounting horizontally correlate to the ground is called as a wind turbine with a horizontal axis (HAWT). The smallest turbines used for applications such as battery charging for boat Auxiliarycontrol. Different process such as FEM (finite element method) positioned ANSYS (Analysis systems) workbench software can be used to design blade profile. The blade is generally used as greater output volumes, but requires considerable investment and consumes more construction space compared to the vertical axis wind turbine blade. It needs installation about wide tower and blade and the cost of transport is almost 16 percent of the cost the equipment. Installation of the horizontal axis wind turbine requires highly skilled labours.The output of the wind turbine on the horizontal axis is greater than that of the wind turbine on the vertical axis.

II .HAWT BLADE DESIGN

Due to its supremacy in the wind turbine industry, an emphasis is now being placed on the horizontal axis windturbine blad e (HAWT). HAWT are very prone to changes in pro file and shape of blades. This section discusses briefl y the main parameters that affect the output of wind t urbine blades at the horizontal. Aluminium, Stainlesssteel, Structural steelandTitanium are used in blade design. Aerodynamic blade made of lightweight carbon fibre has a razor edge that cuts through the wind and it quasi silent.

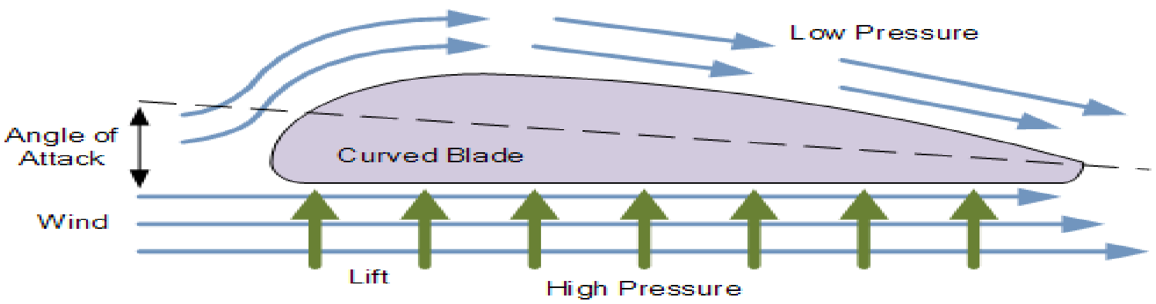

Fig1:Horizontal axis wind turbine blade design

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ISSN: 0193-4120 Page No. 9493 – 9500

Niranjana et al (1) studied the generation about power by wind turbine blade with vertical axis. The capacity generated is discussed by adjusting the windmill on high road ways this study indicates the output of the vertical axis wind turbine can be improved over changing blades length and model. Sulakhe Vishal et.al (2) studied the design and analysis of the jet wind turbine blades developed and measured for the development of 100watts of electricity and create that the performance of jet wind turbine is three to greater than that of traditional wind turbine. D.A.Nikam et al. (3) studied the literature review on design and development of wind turbine blades with vertical axis. Amar C. In this work, et.al (4) conducted structural analysis of a composite wind turbine blade, produced a 5m long wind turbine rotor blade, performed finite element analysis, and both static and dynamic blade behaviour. B.Bavanish et.al (5) found that the optimisation objective was to optimize the performance of aerodynamics at single design wind speeds. The optimized collection obtained at 0.15 blade strength is 5-degree angle of attack 8-degree tip speed ratio.M.Abid et al. (6) studied the design, construction and testing of a wind turbine with the savonius and Darrius vertical axis. This paper shows that wind mill with vertical axis is more effective as compares to wind mill with horizontal axis wind. Kunduru Akhil Reddy et al. (7) researched briefly on wind turbine science, study, design, and review. The paper's primary purpose is to increase a wind turbin e's aerodynamic performance. Ayyadurai et al. (8) pe rformed a vertical axis highway windmill study for i ssue with highways lightning.

III.Design of blade

Blade creation is done in solid works version15. Tur bine blade meshing, version 16 of the ANSYS work benchprogram is used. Wind turbine blade and aerofoil are correctly selected according to dimensions, as are most common design methods.

IV. Static Structural analysis of blade

Static Structural Analysis is a major topic in the blades of the wind turbine performed by Ansys workbench version16.Stress, strain, Deformations in various directions are considered to control the blades protection factor against applied loads. The stresses, strains and deflection values are the most important parameters in static structural analysis of the blades.

V.WIND TURBINE BLADE PROPERTIES

The TABLEI below demonstrate the properties of blade are used as the Analysis. Four specific materials are used in horizontal axis wind turbine blade design, the research is achieved by adjusting their properties.The main objective was to examine the finishing findings said as various values for Stress Distribution that occur when the turbine blade is exposed to the wind strength.

TABLE I

Material	Properties		
	Density, ρ [kg/m³]	Modulus of Elasticity, E [N/mm²]	Poisson’s ratio, υ
Aluminium	2770	7.7e5	0.33
Stainless steel	7750	7.93e5	0.31
Structural steel	7850	2e5	0.3
Titanium	4620	9.6e5	0.36

VI. RESULTS AND DISCUSSION

1. Analysis using aluminium as blade material

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TOTAL DEFORMATION

Total deformation is the vector sum all directional displacements of the systems.

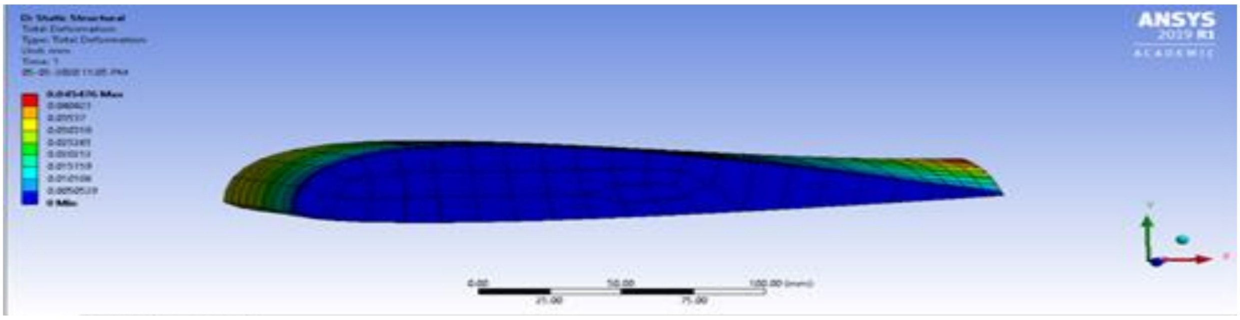

Fig. 2: Total deformation Distribution of Aluminium

Equivalent elastic strain:The elastic strain is assign as the limit for the values of strain up to whatever the object would pick up and come back to the initial frame upon the elimination of the load. When the object is subjected to an external load, it undergoes deformation.

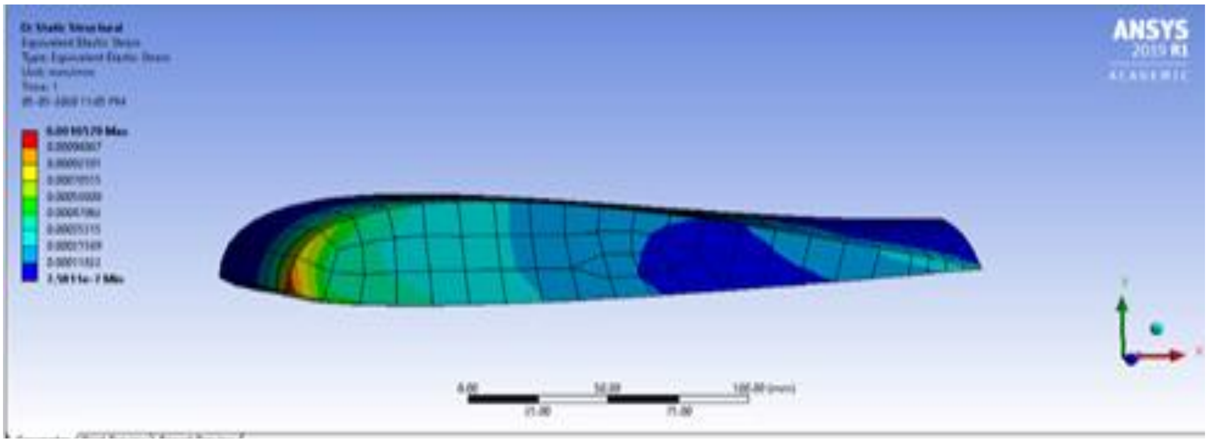

Fig. 3: equivalent elastic StrainDistribution of Aluminium

Equivalent stress

Equivalent stress is used when there is multiaxial stress state with multiple stress components acting at the same time in the structure.

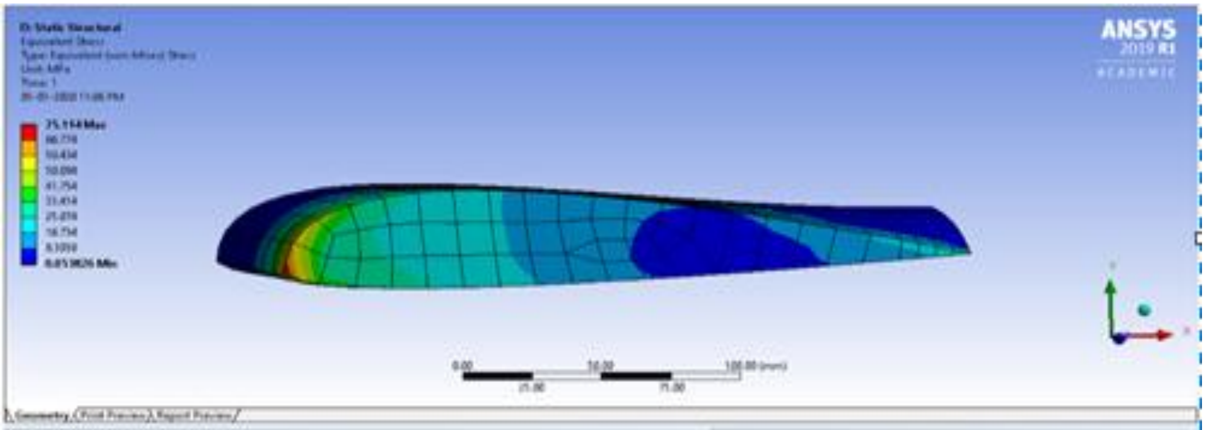

Fig. 4: Equivalent Stress Distribution of Aluminium

2.Analysis using stainless steel as blade material Total Deformation

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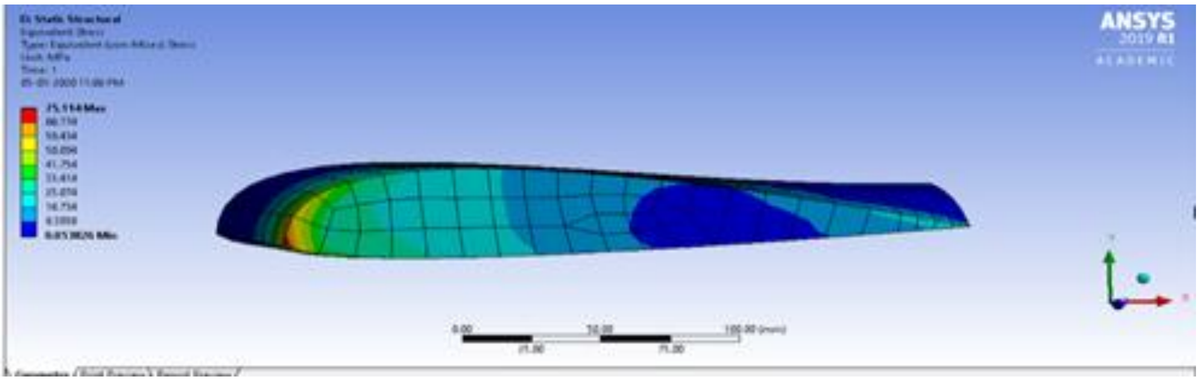

Fig 5: Total DeformationDistribution of stainless steel

Equivalent stress

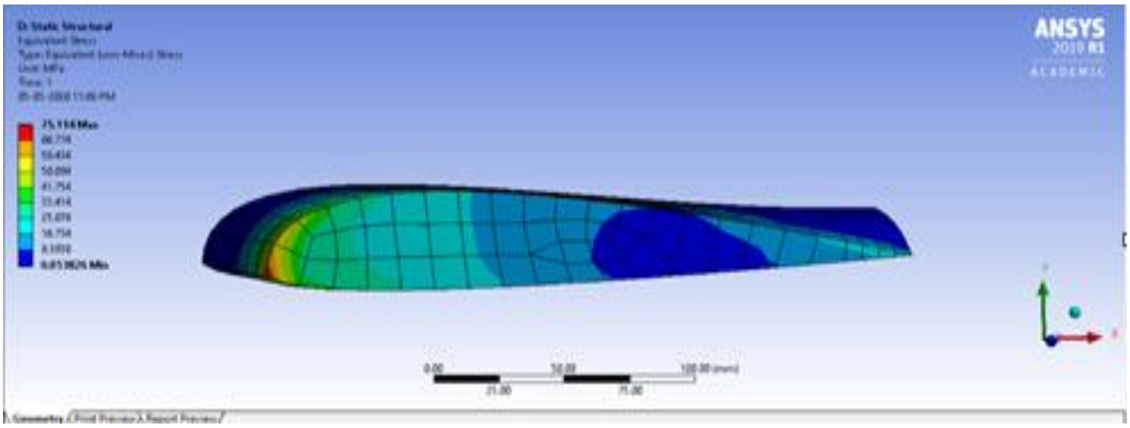

Fig 6: Equivalent stress distribution of stainless steel

Equivalent elastic strain

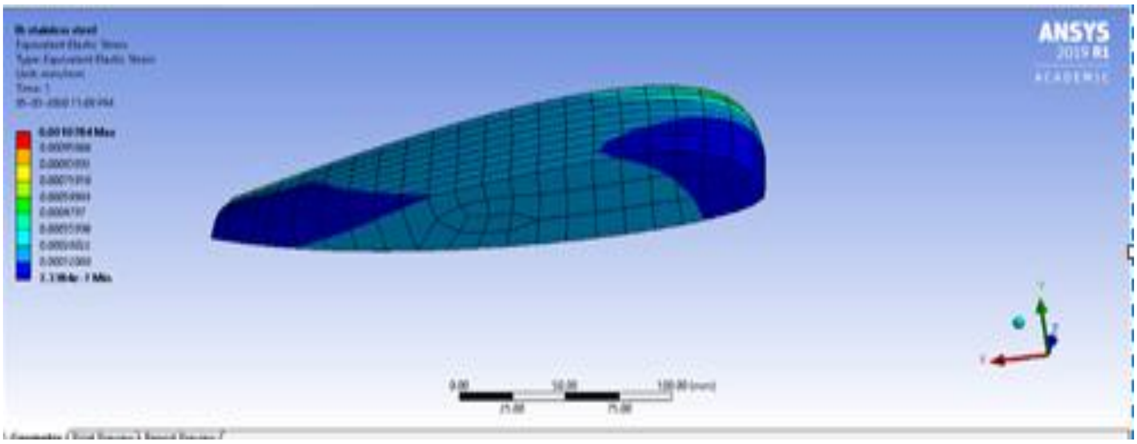

Fig 7: Equivalentelastic strain Distribution of stainless steel

3. Analysis using structural steel as blade material Total deformation

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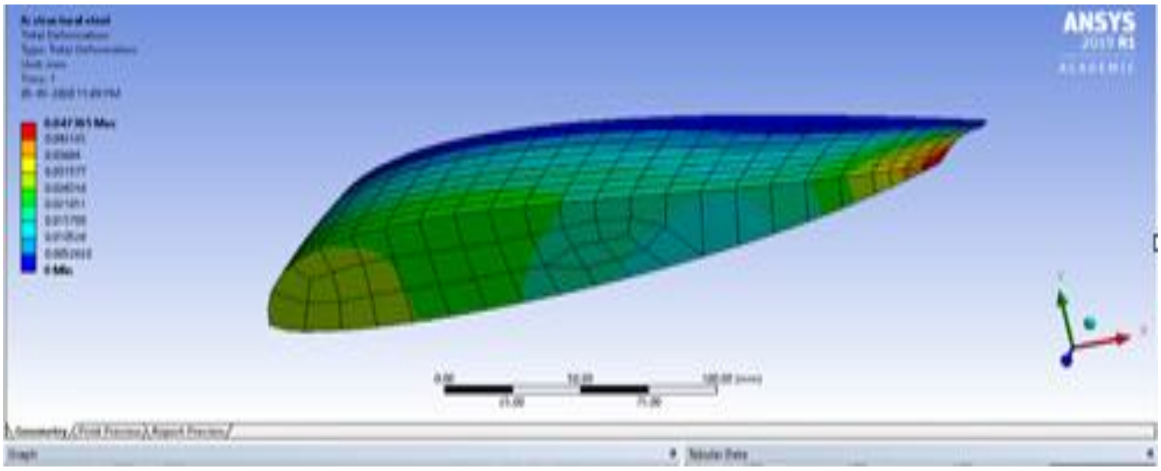

Fig 8: Total Deformation distribution of structural steel

Equivalent stress

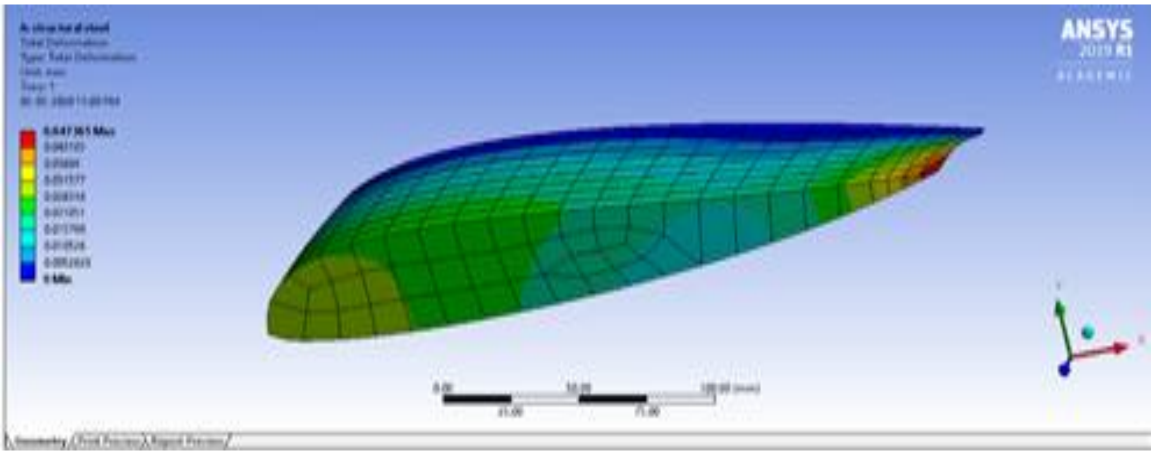

Fig 9: Equivalent stress Distribution of structural steel

Equivalent elastic strain

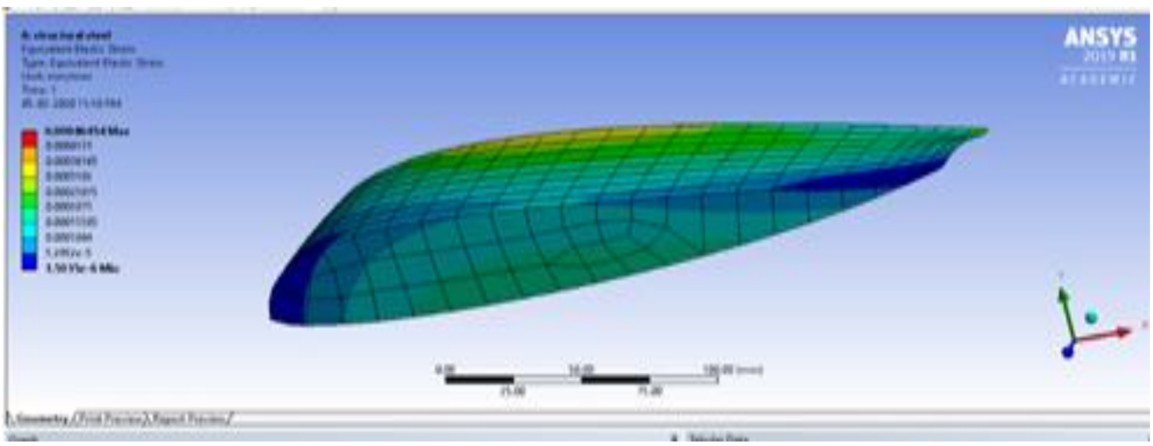

Fig 10: Equivalent elastic strainDistribution of structural steel

4.Analysis using titanium as blade material

Equivalent stress

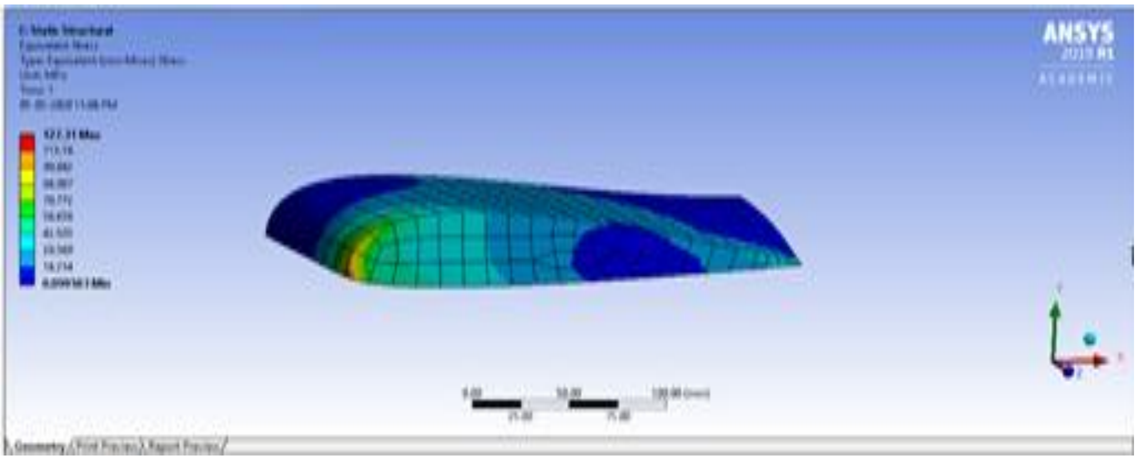

Fig 11: Equivalent stressdistributionofTitanium

Equivalent elastic strain

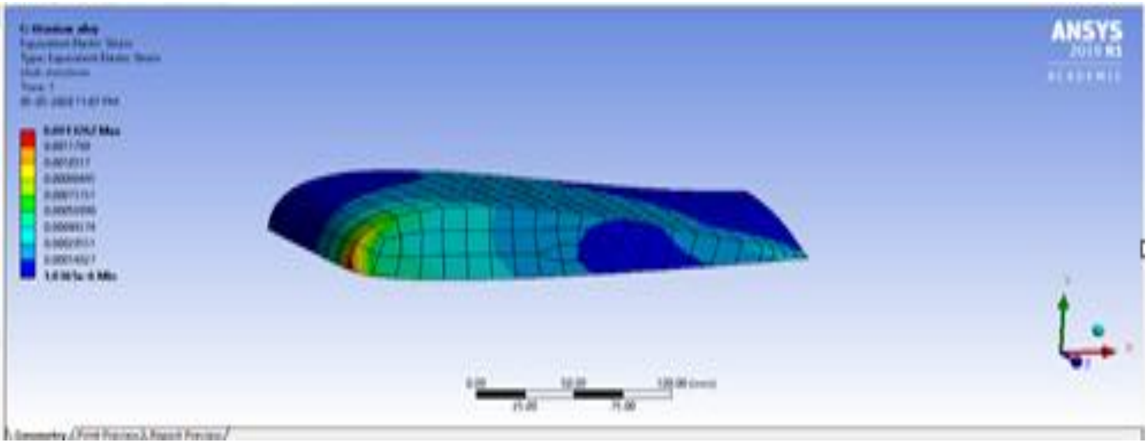

Fig. 12: Equivalent elastic straindistribution of titanium

Total Deformation

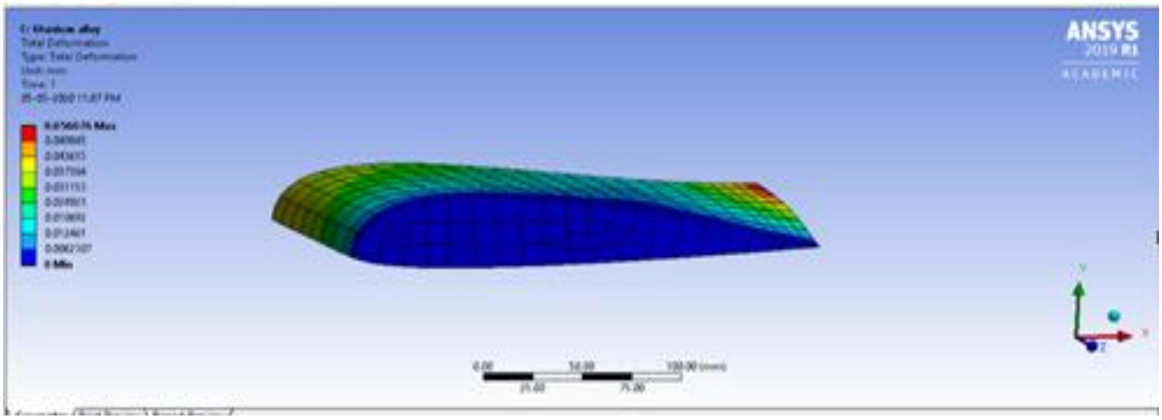

Fig 13: Total deformation distribution of titanium

TABLE IIDisplay the results collect from the static structural analysis complete in ANSYS WORKBENCH. The value of Equivalent stress, Equivalent elastic strain and Deflection are tabularized. Based on the results the perfect material for the horizontal axis wind turbine blade is chosen.

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VII. Resultscomparison

TABLE II

Material	Property					
	stress		Strain		Deflection	
	Max	Min	Max	Min	Max	Min
Aluminium	75.114	0.053826	0.0010579	7.5811*10^-7	0.045476	0
Stainless steel	208.13	0.14163	0.0010784	7.3384*10^-7	0.046788	0
Structural steel	92.909	0.3007	0.00046454	1.5035*10^-6	0.047365	0
Titanium	127.31	0.099503	0.0013262	1.0365*10^-6	0.056076	0

VIII. Conclusion

This paper presents Structural analysis of horizontal axis wind turbine blade using ANSYS-WORKBENCH. The completedanalysis is carried out for aluminium, stainless steel, structural steel and Titanium made wind Turbine. Obtained results shows that Aluminium wind turbine blade has low stress, strain and deformation with compare to the stainless steel, structural steel and Titanium made wind Turbine.

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