International Journal of Engineering Research And Advanced Technology (IJERAT)
ISSN: 24546135 [Volume. 02 Issue.04, April - 2016]

Performance of E-Glass/Epoxy Windmill wound Rotor based on Structural Analysis

Kannan S[1], Dr.Venkatamuni T[2] , Vinoj Kiran I[3]

Jeppiaar Institute of Technology

Chennai, India.

ABSTRACT

This work deals with 2.1 MW 50Hz, 60Hz wind mill induction generator has very flexible and complicated model of rotor the Performance of conventional two-piece steel rotor shaft replaced with a single-piece e-glass/epoxy because of higher specific stiffness and strength of composite materials. Various speeds (Rated speed, overall speed, Critical speed) of wind mill wound rotor is analyzed with conventional steel and e-glass/epoxy materials and choose the best material based on the comparison. This project carries on the design and analysis process for the steel and E-glass/Epoxy materials.

Keyword: *Composite material, Deflection, E-glass/Epoxy materials. Specific Stiffness, Strength, Wind Mill.*

1. INTRODUCTION

Fiber reinforced polymer composites are mainly concentrated in aerospace industries then used for various other technical tasks, where it is beneficial to apply lightweight construction materials which have high strength and stiffness characteristics .The advanced composite materials such as graphite, carbon, Kevlar and glass with suitable resins are widely used because of their high specific strength (strength/density) and high specific modulus (modulus/density). Advanced composite materials seem ideally suited for long, power driver shaft applications. Their elastic properties can be tailored to increase the torque they can carry as well as the rotational speed at which they operate. The rotor shaft is used in windmill, aircraft and aerospace applications

2. COMPOSITE MATERIAL

Composite consist of two or more materials or material phases that are combined to produce a material that has superior properties to those of its individual constituents. The constituents are combined at a macroscopic level and or not soluble in each other. The main difference between composite and an alloy are constituent materials which are insoluble in each other and the individual constituents retain those properties in the case of composites, where as in alloys, constituent materials are soluble in each other and forms a new material which has different properties form their constituents. Classification of composites are Polymer matrix composites1),Metal matrix composites2), Ceramic matrix3).The most important composites are those in which the dispersed phase is in the form of fiber. The design of fibre-reinforced composites is based on the high strength and stiffness on a weight basis. Specific strength is the ratio between strength and density. Specific modulus is the ratio between modulus and density.

3. ROTOR

Rotor unbalance is the most common reason in machine vibrations. Most of the rotating machinery problem can be solved by using the rotor balancing and misalignment. Mass unbalance in a rotating system often produces excessive synchronous forces that reduce the life span of various mechanical elements. A very small amount of unbalance may cause severe problem in high speed rotating machines. Simply supported rotors are used in many engineering applications. The vibration signature of the simply supported rotor is totally different from the centre hung rotors. The vibration caused by unbalance may destroy critical parts of the machine, such as bearings, seals, gears and couplings. Rotor unbalance is a condition in which the centre of mass of a rotating assembly, typically the shaft and its fixed components like disks and blades etc. is not coincident with the centre of rotation. In practice, rotors can never be perfectly balanced because of manufacturing errors such as porosity in casting, non-uniform density of material, manufacturing tolerances and gain or loss of material during operation As a result of mass unbalance, a centrifugal force is generated and must be reacted against by the bearings and support structures.

Figure.1 Wound Rotor Design

Real structures, components or domains are in general very complex, and have to be reduced to a manageable geometry. Curved parts of the geometry and its boundary can be designed using curves and curved surfaces. However, it should be noted that the geometry is eventually represented by a collection of elements, and the curves and curved surfaces are approximated by piecewise straight lines or flat surfaces, if linear elements are used.

4. TECHNICAL SPECIFICATION AND PROPERTIES

4.1 Data for Spider Shaft

Mass of the spider shaft	= 760 kg
Length of the spider shaft	= 2745.5 mm
Overhang after the bearing end faces@ DE (42 kg overhang)	= 310mm
Overhang after the bearing end faces@ NDE (24 kg overhang)	= 417 mm
Length of the shaft for calculation (2745-310-417+34+31) L	= 2018.5 mm

Mass of the spider shaft = 694 kg

Total mass of the shaft = 1400839 kg-mm

Equivalent diameter of shaft = 237 mm

4.2 Data for Rotor Core and Winding

Mass of the rotor core = 1510 kg

Mass of the rotor winding = 460 kg

Total mass of the wound rotor without shaft = 1970 kg

Total mass of the wound rotor with shaft = 2730 kg

4.3 Properties for Materials

Table: 1 Material property

Mechanical properties	Symbol	Units	Steel	E-Glass/Epoxy
Young's modulus	E	GPa	207	50
Shear modulus	G	GPa	80	5.6
Poisson's ratio	γ	----	0.3	0.3
Density	ρ	Kg/m3	7600	2000
Yield strength	Sy	MPa	370	72

5. RESULTS AND DISCUSSION

A. Analysis Result for Steel (SM45C)

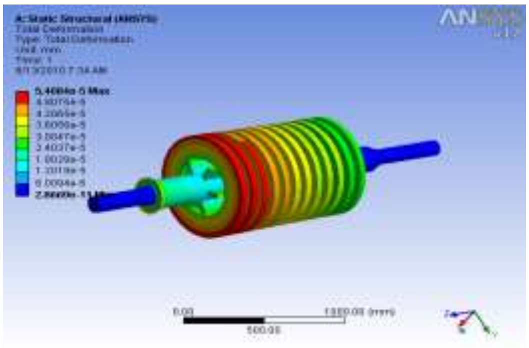

Fig.2.50 Hz Rated Speed (1512rpm)

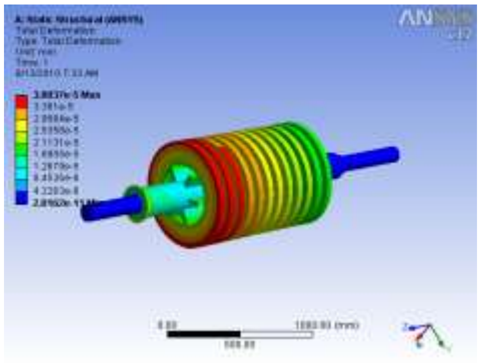

Fig.3. 50Hz over Speed (2150rpm)

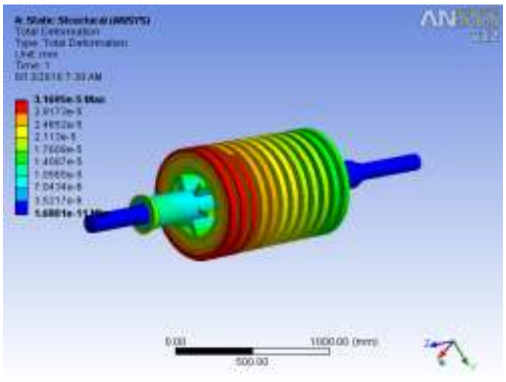

Fig.4.50Hz Critical Speed (2580rpm)

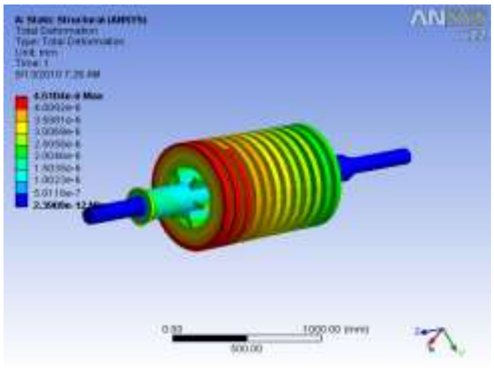

Fig .5. 60 Hz Rated Speed (1812 rpm)

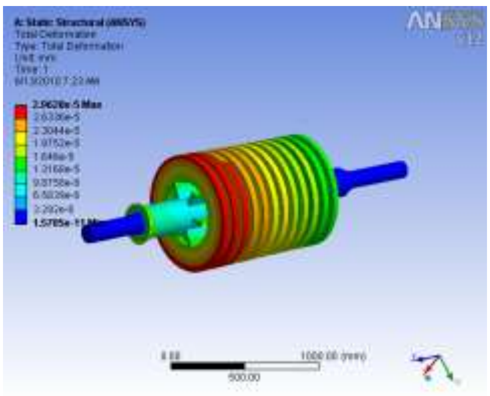

Fig.6.60Hz over Speed (2760rpm)

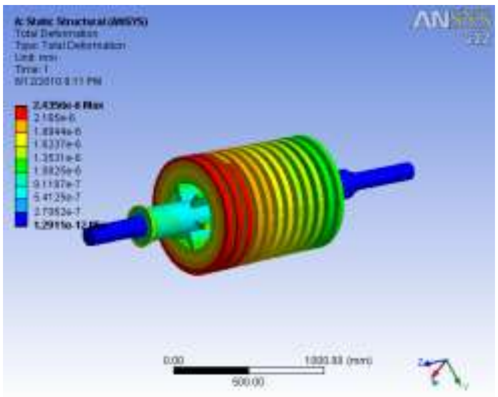

Fig.7.60Hz Critical Speed (3312rpm)

B. Analysis Result for EGLASS/EPOXY

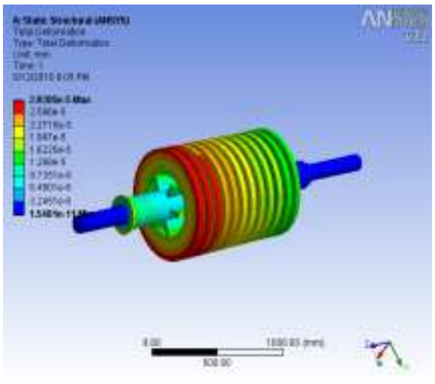

Fig.8.50 Hz Rated Speed (1512rpm)

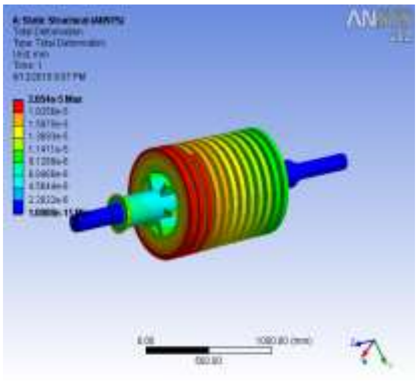

Fig.9.50Hz over Speed (2150rpm)

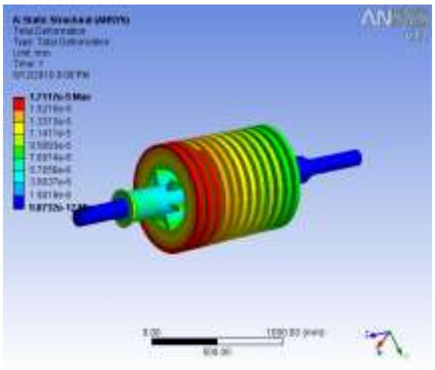

Fig.10.50Hz Critical Speed (2580rpm)

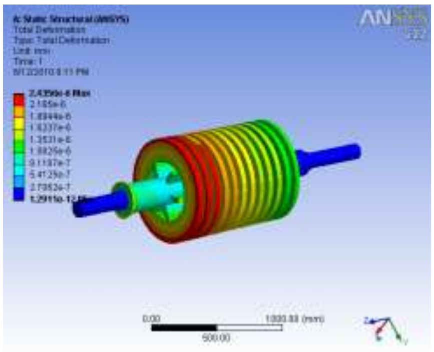

Fig.11.60 Hz Rated Speed (1812 rpm)

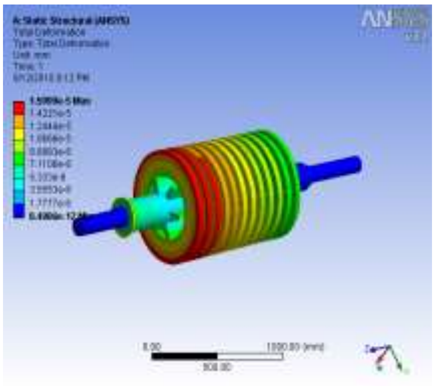

Fig.12.60Hz over Speed (2760rpm)

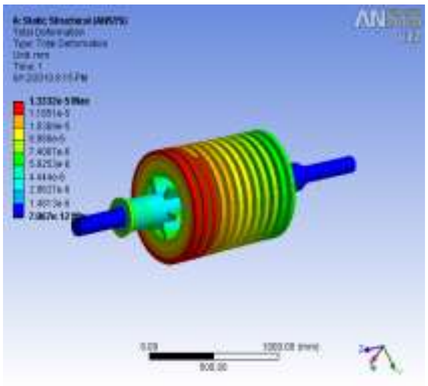

Fig.13.60Hz Critical Speed (3312rpm)

Table: 2 Comparison of Analysis Result

		STEEL (SM45C)			E-GLASS/EPOXY		
		Deflection (mm)	Stress (N/mm^2)	Strain	Deflection (mm)	Stress (N/mm^2)	Strain
50Hz Generator	Rated speed	5.4×10^{-5}	0.018	6.6×10^{-7}	2.9×10^{-5}	0.018	3.6×10^{-7}
	Over Speed	3.8×10^{-5}	0.012	4.7×10^{-7}	2.05×10^{-5}	0.012	2.5×10^{-7}
	Critical Speed	3.1×10^{-5}	0.010	3.9×10^{-7}	1.7×10^{-5}	0.010	2.1×10^{-7}
60Hz Generator	Rated Speed	4.5×10^{-6}	0.0015	5.5×10^{-8}	2.4×10^{-6}	0.0015	3.01×10^{-8}
	Over Speed	2.9×10^{-5}	0.0099	3.6×10^{-7}	1.5×10^{-5}	0.0099	1.9×10^{-7}
	Critical Speed	2.4×10^{-5}	0.0082	3.05×10^{-7}	1.3×10^{-5}	0.0082	1.6×10^{-7}

5. CONCLUSION

This paper shows the 2.1MW 50Hz and 60Hz Generator at various speeds (Rated, Over, Critical) wound rotor in the application of wind mill was analyzed after the design using ANSYS for the conventional STEEL material and E-GLASS/EPOXY composite material. Based on the Deflection, Stress and Strain results E-GLASS/EPOXY composite material proves as the better performance rather than the STEEL, using the composite material deflection was reduced based the deflection vibration and noise also minimized then got the high specific stiffness and strength properties.

REFERENCES

[1]. K.Devendra1, and T. Rangaswamy, “Evaluation of Thermal Properties of E-Glass/ Epoxy Composites Filled By Different Filler Materials”, InternationalJournal Of Computational Engineering Research, vol. 2,Issue. 5, pp.1708–1714,Sep.2012.

[2]. Abdul Nazeer, “Parametric Studies of Low Velocity Impact on E-glass/Epoxy using Ls-Dyna”, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), vol. 11,Issue. 4, pp.33–39,(Jul- Aug. 2014).

[3]. VijaykiranBura and Praveen, “Testing the Flexural Fatigue Behavior of E-glass Epoxy Laminates”, International Journal of Research in Engineering and Technology, vol. 3,Issue. 8, pp.224–241,Jul. 2014.

[4]. Y. Haribabu, and Devi Prasad, “Effect of Nano particles on E-Glass Fiber Epoxy Resin Composites,”International Journal of Modern Engineering Research, vol. 5, Issue.1, pp. 65–69, Jan. 2015.

[5]. Sandip A. Kale1 , Dr. S. N. Sapali, “Comprehensive Evaluation of Innovative Multi Rotor Wind Turbine Designs,”International Journal of Mechanical Engineering and Technology (IJMET), vol. 3, Issue.2, pp.730–739, May-August (2012).