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Design and analysis of Composite Transmission Shaft

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ABSTRACT

The Transmission Shaft made of Steel material is used to transmit power from turbine to generator. The Steel shaft are subjected to various load and torsional stress, due its heavy weight a large amount of vibration is produced on the rotating body this leads to breakage of the shaft. This Steel shaft has greater Critical Speed at low Frequency, less Stiffness and more weight which are the major drawback of the Steel material. There arises a need to replace the conventional Shaft by a Composite Shaft. It makes possible to design a Shaft of EPOXY EGLASS UD Composite material with less weight which increase natural frequency. This Composite Material has High Specific Stiffness and Strength. The reduction in weight impacts overall weight of the system, when weight is reduced more power is utilized. These Properties of the Composite material enhances the performance of the system.

KEY WORDS: Critical Speed, EPOXY EGLASS UD, Transmission shaft, turbine, Generator.

1. INTRODUCTION

Composite materials have improved the performance of various structures when compared to conventional materials. Bhajantri (2014), suggests composites to incorporate in place of conventional materials, as they have superior stiffness and high strength to weight ratio for better performances of various structures. The composite material of the shaft is utilized on having less weight. Anirudha (2015), states that reduction in weight of the shaft reduces the general weight of the system which makes available of more power during transmission. Arun Ravi (2014), analysed the shaft made of composite material, it is known that weight saving of the high strength carbon is up to 24% in hollow shaft where energy is conserved. High specific stiffness of the composite material enhances strength of shaft. Sagar (2013), describes the substitutional material's high specific stiffness and strength increases the advantages over the conventional steel shaft. To maintain stability in any rotating structure, it should be vibration free; in conventional material shaft it is not possible. Chang (2004), analysed the natural frequencies, critical speed and stability of the composite shaft, effective than conventional shafts due to light weight, stiffness and high damping capacity. Vibrations are reduced in higher level that gradually increases the stability of the system. Parshuram (2013), estimates the deflection, stresses and natural frequencies using Finite Element Analysis, which are less compared to steel shafts. The composite materials offer excellent damping of vibration. Rangaswamy (2005), describes the composite shaft favours in weight reduction, dynamic balancing increases operation speed, long fatigue life.

2. DESIGN AND ANALYSIS of STEEL AND COMPOSITE MATERIAL

Material: Steel (S355), Shaft Diameter: 80 mm, Shaft Length: 1900.45 mm

Fig.1. Geometry structure

Meshing: Min size: 2.0 mm, Max size: 10.00 mm.
Method: Tetrahedrons (Solid 187).
Statistics: Nodes: 28758, Element: 98662.

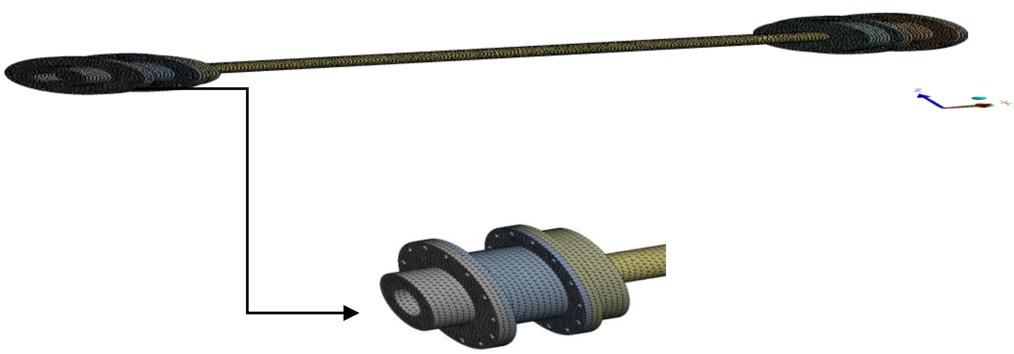

Fig. 2. Meshing

Boundary Conditions: Radial: Fixed, Axial: Free, Tangential: Fixed.

Fig.3. Cylindrical Support

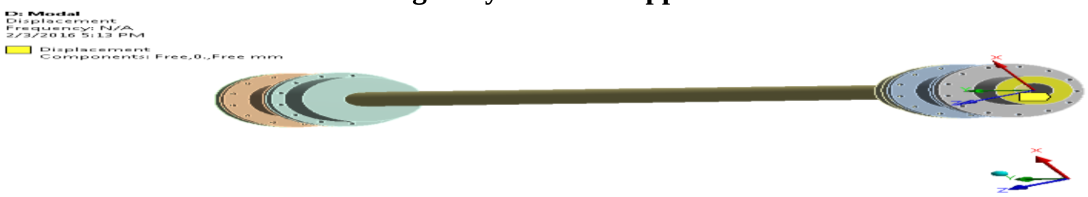

Fig.4. Displacement

Min: 100 RPM; Max: 2895 RPM; Rotational Velocity: 2895 RPM

Fig.5. Rotational velocity

Material: EPOXY EGLASS UD, Shaft Inner Diameter: 40 MM, Shaft Outer Diameter: 80MM, Length: 2000 MM

Meshing: Method: Tetrahadron, NODES: 131856, ELEMENT: 476791.

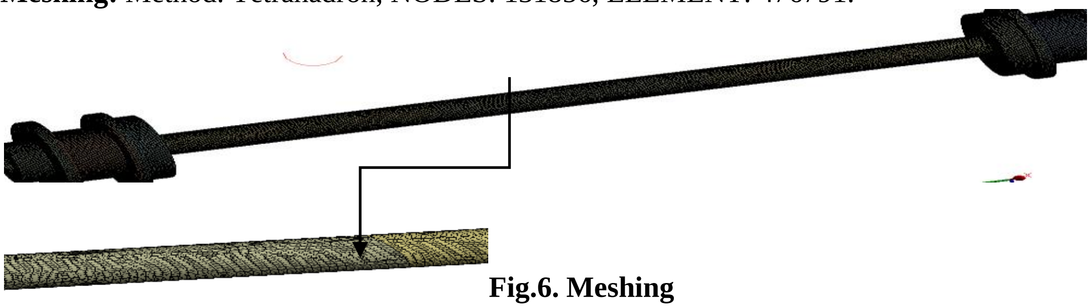

Fig.6. Meshing

Boundary Conditions

Fig: 7. Fixed support

Moment: 3630240 N-MM

Fig.8. Moment

3. RESULTS AND DISCUSSION

Static Structural:

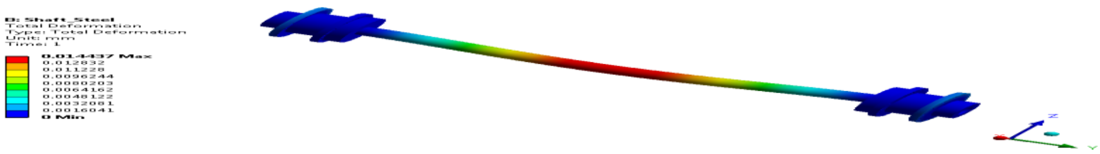

Fig.9. Total Deformation (Steel)

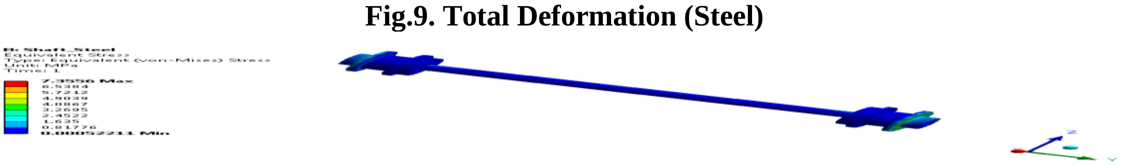

Fig.10. Equivalent Stress 1(Steel)

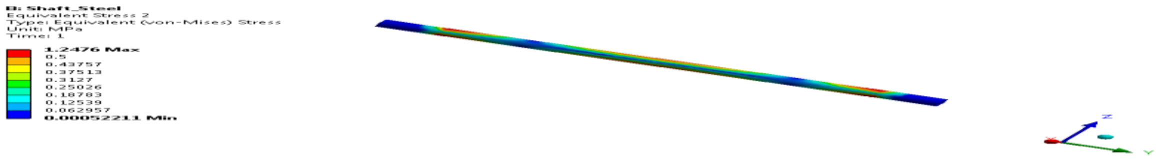

Fig.11. Equivalent Stress 2 (Steel)

The Total Deformation of Steel Shaft with time is calculated and values obtained are Maximum Deformation is 0.014437 and Minimum Deformation is 0. The Equivalent Stress is calculated and the Maximum Stress is 7.3556 and Minimum Stress is 0.00052211

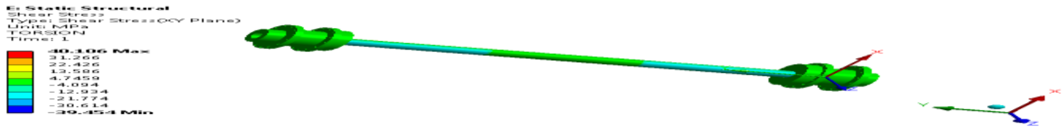

Fig.12. Shear Stress (Composite)

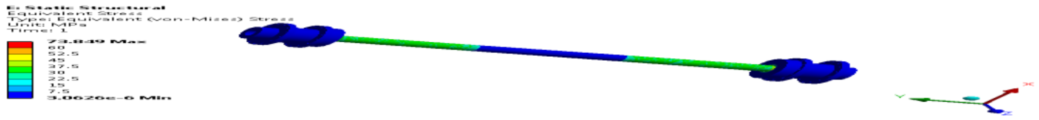

Fig.13. Equivalent Stress 1 (Composite)

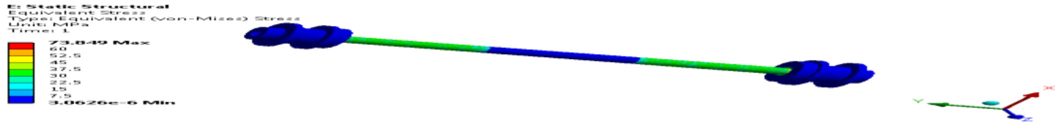

Fig.14. Equivalent Stress 2 (Composite)

Shear Stress along the Shaft is obtained are Maximum is 40.106 and Minimum is -39.454. Calculated Equivalent Stress are Maximum is 73.849 and Minimum is 3.062e-6.

Model Analysis:

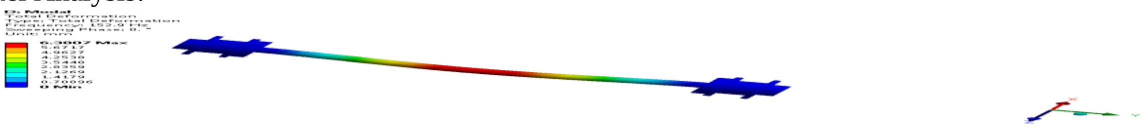

Fig.15. Total Deformation 1 (Steel)

Fig.16. Total Deformation 2 (Steel)

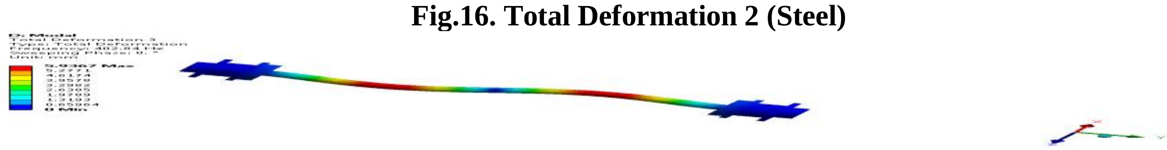

Fig.17. Total Deformation 3 (Steel)

Fig.18. Total Deformation 4 (Steel)

Fig.19. Total Deformation 5 (Steel)

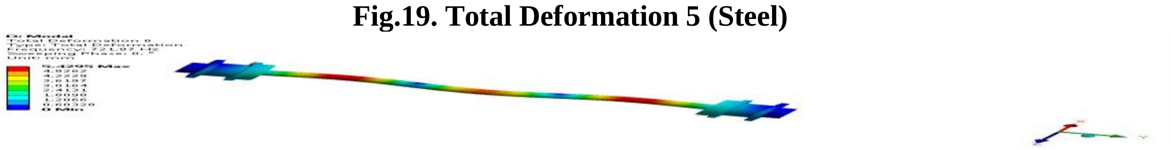

Fig.20. Total Deformation 6 (Steel)

Fig.21. Total Deformation 7 (Steel)

The Total Deformation of Steel Shaft for various frequencies are analysed and the Maximum value obtained is 5.9331 and Minimum value is 0 for the frequency of 403.4 Hz.

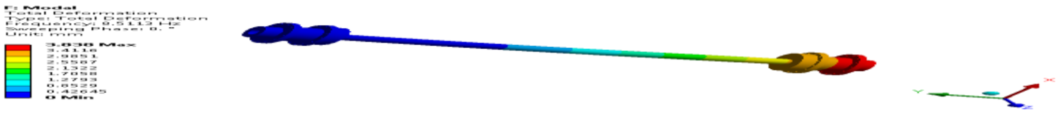

Fig.22. Total Deformation 1 (Composite)

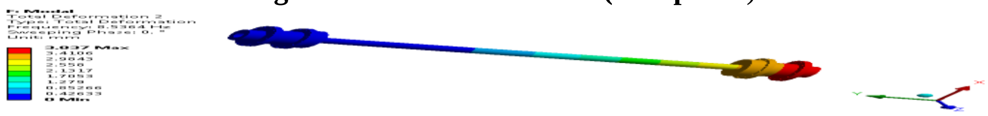

Fig.23. Total Deformation 2 (Composite)

Fig.24. Total Deformation 3 (Composite)

Fig.25. Total Deformation 4 (Composite)

Fig.26. Total Deformation 5 (Composite)

Fig.27. Total Deformation 6 (Composite)

The Total Deformation of Composite Shaft for various frequencies are studied and values obtained are Maximum is 6.4843 and Minimum is 0 for the frequency of 250.27 Hz.

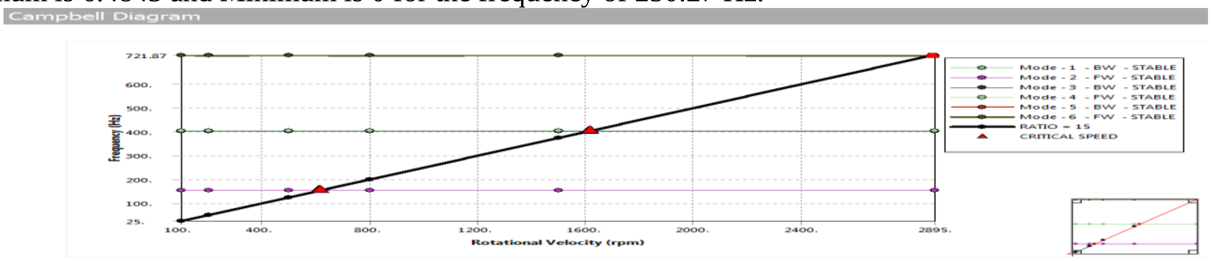

Fig.28. Campbell Diagram (Steel)

The Campbell Diagram for Steel Shaft representing Frequency versus Rotational Velocity is plotted. That show Critical Speed of Shaft at various frequency on Forward Whriling.

Table.1. Table for Deformation (Steel)

Mode	Whirl Direction	Mode Stability	Critical Speed	100 Rpm	200 Rpm	500 Rpm	800 Rpm	1500 Rpm	2895 Rpm
1	BW	STABLE	611.58	152.9	152.9	152.9	152.9	152.9	152.9
2	FW		612.37	153.09	153.09	153.09	153.09	153.09	153.09
3	BW		1611.4	402.84	402.84	402.84	402.84	402.84	402.84
4	FW		1613.6	403.4	403.4	403.4	403.4	403.4	403.4
5	BW		2885.3	721.33	721.33	721.33	721.33	721.33	721.33
6	FW		2887.5	721.87	721.87	721.87	721.87	721.87	721.87

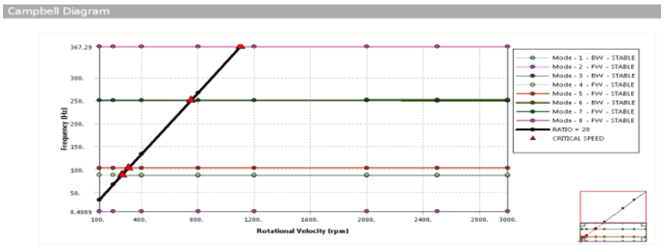

Fig.29. Campbell Diagram (Composite)

The Campbell Diagram for Composite Shaft representing Frequency versus Rotational Velocity is plotted. That shows the Critical Speed of Shaft at various frequency on Forward Whirling.

Table.2. Table for deformation (Composite)

Mode	Whirl Direction	Mode Stability	Critical Speed	100 Rpm	200 Rpm	400 Rpm	800 Rpm	1200 Rpm	2000 Rpm	2500 Rpm	3000 rpm
1	BW	STABLE	NONE	8.5113	8.5113	8.5101	8.5101	8.5087	8.5048	8.502	8.4989
2	FW		NONE	8.5364	8.5365	8.5376	8.5376	8.5391	8.5429	8.5458	8.5488
3	BW		261.31	87.124	87.112	87.085	87.027	86.849	86.819	86.775	86.712
4	FW		261.58	87.173	87.184	87.21	87.269	87.447	87.447	87.522	87.59
5	FW		307.84	102.61	102.61	102.61	102.61	102.61	102.61	102.61	102.61
6	BW		750.33	250.27	250.2	250.3	250.1	249.77	249.77	249.63	249.5
7	FW		751.61	250.38	250.44	250.44	250.55	250.88	250.88	251.03	251.16
8	FW		1101.9	367.29	367.21	367.29	367.29	367.21	367.29	367.29	367.29

4. CONCLUSION

Following Conclusions are obtained from the above Finite Element Analysis results:

a) The Replacement of Conventional Steel Shaft by Composite material has resulted in considerable weight saving which makes available of surplus power.

b) The Composite material reduces the vibration produced in the transmission shaft compared to the Conventional shaft, because of the vibration damping capacity of the Composite material.

c) The Analysis indicates that Critical Speed of the Composite Shaft are less even on higher Frequency.

d) These results are encouraging to use Composite material for effective and efficient performance of Transmission Shaft.

REFERENCES

Anirudha P. Jangam, Vishavjit L, Design and Analysis of Drive Shaft In Automotive Using Composite Material, 3 (4), 2015.

Arun Ravi, Design, Comparison and Analysis of a Composite Drive Shaft for an Automobile, International Review of Applied Engineering Research, 4, 2014, 21-28.

Bhajantri V.S, Bajantri S.C, Design and analysis of Composite Drive Shaft, International Journal of Research In Engineering and Technology, 3 (3), 2014.

Chang M.Y, Chen J.K, and Chang C.Y, A simple Spinning Laminated Composite Shaft Model, International Journal of Solids and Structures, 41, 2004, 637-662.

Parshuram D, Sunil Mangsetty, Design and Analysis of Composite/Hybrid Drive Shaft for Automotives, The International Journal of Engineering And Science (IJES), 2 (1), 2013, 160-171.

Rangaswamy T, Vijayarangan S, Optimal sizing and stacking of Composite Drive Shafts, Materials science, II (2), 2005.

Sagar R Dharmadhikari, Sachin G Mahakalkar, Design and Analysis of Composite Drive Shaft using ANSYS and Genetic Algorithm, International Journal of Modern Engineering Research, 3 (1), 2013, 490-496.