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Random Vibration Analysis Of Composite Drive Shaft for Automotive Application

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Abstract: Vibration plays an important role in designing drive shafts because failure due to vibration is more prominent compared to material failure. In this direction, an attempt has been made to study the suitability of Kevlar49/Epoxy composite drive shafts for automotive driveline application from vibration point of view. Random vibration analysis has been carried out for steel and Kevlar49/Epoxy drive shaft having optimized stacking sequence, number of layers, and layer thickness has been obtained from particle swarm optimization (PSO) technique. Using FE solver ANSYS 10, the results obtained have been compared with experimental values and found to be satisfactory.

Keywords: Composite Drive Shaft, Random Vibration, Random Vibration Analysis, Shear Strength

I. INTRODUCTION

In recent years many researchers have worked in the direction to replace a two-piece drive shaft with a single piece shaft without sacrificing the functional requirements. Vibration exists when a system responds to some internal or external excitation. A random vibration is one whose value is not predictable at any point in time. Random vibration analysis predicts the response of a system that is subjected to a nondeterministic continuous excitation. Since the loading is nondeterministic, it can be characterized only in a statistical sense, for analysis the excitation is assumed as stationary and ergodic. Ramamurti et al. [3] have studied the bus body vibration on smooth and rough road. Karuppiah et al. [1] have conducted vibration analysis of a light passenger vehicle using a half car rigid body model using finite element method. Manjunath et al. [2] have used particle swarm optimization technique to optimize the stacking sequence, number of layers and ply thickness to fulfill the functional requirement of drive shaft. In this paper, an attempt has been made to create finite element model of Steel SMC45 and Kevlar49/Epoxy composite drive shafts for the results obtained from particle swarm optimization technique [2] to analyze the suitability of one-piece composite drive shaft from of random vibration point of view.

II. PROBLEM DESCRIPTION

Generally, the bending natural frequency of a shaft is inversely proportional to the square of the unsupported (beam) length and directly proportional to the square root of specific modulus. Therefore, lesser the length of a shaft between supports, the overall weight of a single shaft will become less for a given material. Hence the conventional steel drive shafts (propeller shafts) of a commercial vehicle are usually made in two pieces, which leads to increased fundamental bending natural frequency. The drive shaft of a commercial vehicle made in two sections connected by a support structure, bearings and U-joints is shown in Fig. 1.

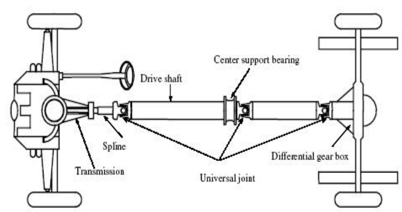

Fig. 1 Schematic Diagram of the Drive Shaft for a Rear Wheel Driving Vehicle [2]

III. RANDOM VIBRATION ANALYSIS

Finite element model of steel and Kevlar49/Epoxy drive shafts has been developed for the optimized results have been obtained from particle swarm optimization [2] using ANSYS V 10 solver. The geometry and material properties of steel and composite drive shaft considered are

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shown in Tables 1 and 2 respectively. The element considered for modeling steel and composite shaft are shell 93 and shell 99 respectively. For random vibration analysis the excitation is assumed as stationary and ergodic.

Table 1 Geometrical Properties of Steel and Kevlar49/Epoxy shafts [2]

Parameter	Optimum Layers	Thickness t(mm)	Optimum Stacking sequence	T (Nm)	Weight(N)	Weight* saving %)
Steel (SM45C)	-	3.32	-	3501	86.04	-
Kevlar49/ Epoxy	17	6.8	[-46/73/39/50 /-43/20/ -24/ -43/$\overline{38}$] s	3519	33.33	61.26

Table 2 Material properties of Kevlar49/Epoxy shaft [2]

Material	**E_x (GPa)**	**E_y (GPa)**	**G_{xy} (GPa)**	**V_{12}**	**Density (Kg/m^3)**
Kevlar49/Epoxy	21.02	16.15	15.74	0.65	1500

An automobile moving on smooth or rough road is subjected to random base excitation. The road profiles are measured for some portions of rough road for vehicle moving with speed of 30 km/hr. Initially the road profiles are measured in time domain and converted in to frequency domain (power spectral density) using fast Fourier transformer as shown in Fig.2 and Fig.3 respectively.

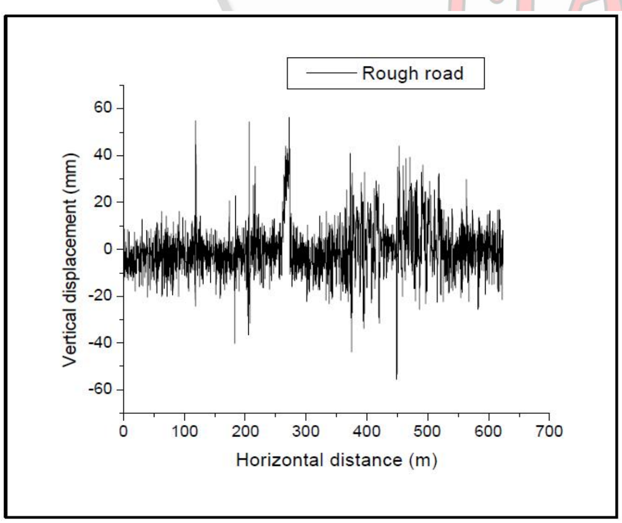

Fig. 2 Rough Road Profile[1]

IV. Analysis for Rough Road Excitation

To carry out random vibration analysis, first modal analysis has been performed with pinned-pinned boundary conditions and then spectrum analysis has been carried out for rough road profile. The power spectral density load is applied on bottom of the shaft for rough road undulations. The shear stress and Von mises stress distribution obtained for steel and Kevlar 49/Epoxy have been shown in figures 5 to 8 respectively

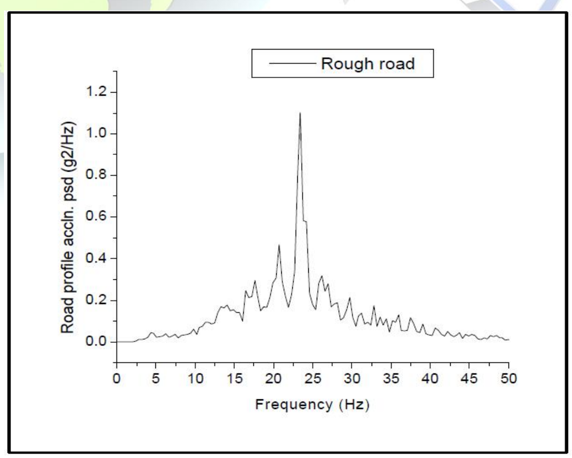

Fig. 3 Rough Road Profile Acceleration

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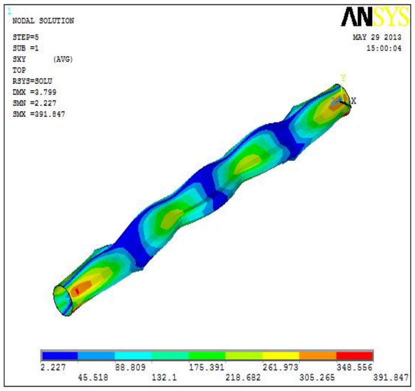

Fig. 4 Shear Stress Distribution for Steel Drive Shaft

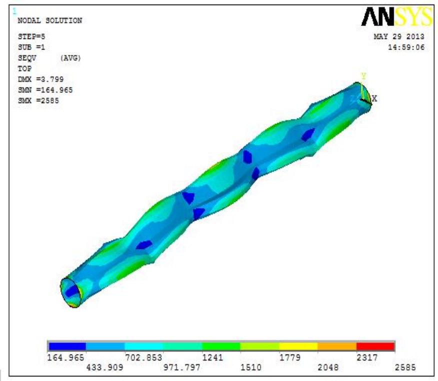

Fig. 5 Von Mises Stress Distribution for Steel DriveShaft

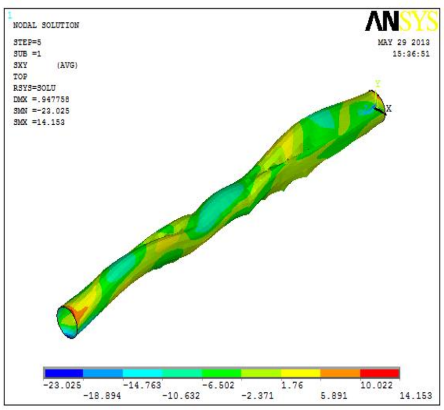

Fig. 6 Shear Stress Distribution for Kevlar49/Epoxy Drive Shaft

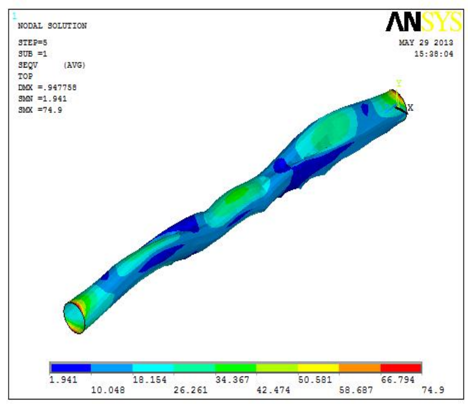

Fig. 7 Von Mises Stress Distribution for Kevlar49/Epoxy Drive Shaft

V. Results and Discussion

The results of random vibration analysis for rough road excitation for steel and Kevlar49/Epoxy drive shafts are tabulated in Table 3 and 4 respectively.

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Table 3 Comparison of Shear Strength Results

Description	Steel	Kevlar49/ Epoxy
Theoretical shear stress(MPa)	175	461
Shear stress from FEA(MPa)	391.85	14.15
Displacement FEA(mm)	3.79	0.95
Factor of safety	0.45	49.1

Table 4 Comparison of Von Mises Stress Results

Description	Steel	Kevlar49/ Epoxy
Theoretical Von missesstress (MPa)	370	1400
Von missesstress from FEA (MPa)	2585	74.9
Factor of safety	0.15	18.7

The shear and von misses stress obtained from FEA is compared with theoretical values. From Tables 3 and 4, may be is observed that the yield strength for steel shaft exceeds the limiting value and not suitable for single piece drive shaft application. The factor of safety of the Kevlar 49/Epoxy shaft is comparatively greater. The displacement of the Kevlar 49/Epoxy is comparatively less than that of steel, hence the vibration carrying capacity is more in Kevlar 49/Epoxy shaft than conventional steel drive shaft because it depends on the stiffness and cross section of the material.

VI. Validation

The acceleration response obtained from FEA for rough road excitation is shown in Fig.9 and it matches with experimental acceleration response as shown in Fig.10 [1].

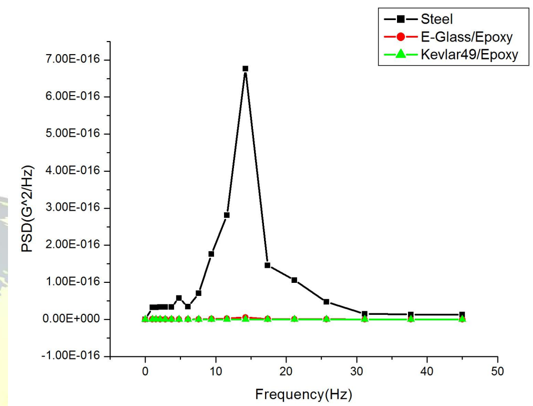

Fig. 8 Acceleration Response Shaft for Rough Road Excitation

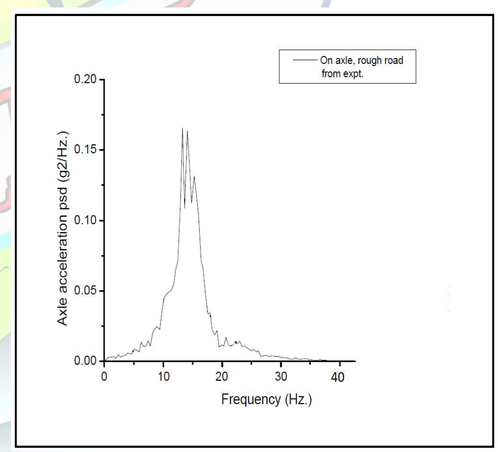

Fig. 9 Acceleration Response of Axle for Rough Road Excitation [1]

VII. Conclusion

- Random vibration analysis has been carried out for Steel and Kevlar49/Epoxy drive shafts using ANSYS V 10 solver.
- Experimental and FEA results are in good

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agreement with each other.

- The optimized single piece Kevlar49/Epoxy composite drive shaft have higher vibration withstanding capacity and factor of safety that makes better suitable for driveline applications.

References

1. Karuppaiah N, Sujatha C, and Ramamurti V, “Numerical Analysis of Vibration Response in a Light Passenger Vehicle”, IMAC-XX, Vol.4753, 2002.
2. Manjunath K,Mohan Kumar S, and Channakeshava K.R., ‘’Ply Stacking Sequence Optimization of Composite Driveshaft using Particle Swarm Optimization Algorithm’’ International Journal of Mechanical Engineering & Technology (IJMET), Vol. 1, No. 1,2010, pp. 74–93.
3. Ramamurthi and Sujatha C, “Bus Vibration Study-Theoretical response analysis and experimental verification”, International Journal of Vehicle Design, Vol. 11(4/5), 1990, pp 401-409.
4. William Thompson, Chandramauli Padbmanabhan, “Theory of Vibration with Applications”, Pearson 2011.
5. B. James Prasad Rao, D. V Srikanth, T.Suresh Kumar, and L.Sreenivasa Rao, “Design and Analysis of Automotive Composite Propeller Shaft Using FEA,” Mater. Today, Proc., vol. 3, no. 10, pp. 3673–3679, 2016.