Design and Vibrational Analysis of Propeller Shaft

S. Varun Raj[1], R. Kumar[1], P. Prakash[1],C.Dhanasekaran[2]

[1]*Assistant Professor, Department of Mechanical Engineering, Vels Institute of Science, Technology & Advanced Studies, Chennai*

[2]*Associate Professor, Department of Mechanical Engineering, Vels Institute of Science, Technology & Advanced Studies, Chennai*

E-mail: varunraj.se@velsuniv.ac.in

Abstract

Propeller shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them. Propeller shaft is used along with a Universal coupling. Universal coupling is a joint in a rigid rod that allows the rod to bend in any direction, and is commonly used in shafts that transmit rotary motion. While transmitting the motion the propeller shaft is subjected to high torsion as well as propeller rotated in high rpm will be vibrated under high frequency. Due to the high frequency vibration, propeller shaft near the coupling joint loses its strength so that they get dismantled or brooked frequently. The main objective of this project is to overcome this problem by making design changes in the propeller shaft and universal joint and analyzing the resulting design. The Propeller shaft can be modeled using Pro-E wildfire3.0 software and then the model is imported to the analysis software ANSYS 8.1. In this analysis software, the redesigned propeller shaft's structural and vibration analysis is carried out and then the result is compared with the existing propeller shaft design.

Keywords: *Propeller shaft, vibration, simulation*

1. Introduction

Consider the propeller shaft mostly applied in Tata Motors' 8-wheeler trucks. A universal joint is a joint in rigid rod that allows rod to bend at any direction, and mostly used in shafts that transmit rotary motion. It consists of a pair of the hinges located close together, oriented at 90° to each other, connected by a cross shaft. The Cardan joint suffers from one important problem: even when the drive shaft axle rotates at a regular speed, the driven shaft axle rotates at a variable speed, it cause vibration and wear.

2. Literature Survey

Bauchau improved procedure for the optimum design of high-speed composite drive shaft made of laminates to increase first natural frequency of the shaft and to decrease the bending stress. Shell theory based on the critical speed analyses of drive shafts has been presented by Dos Reis et al . Patricia L.Hetherington investigated the dynamic behavior of supercritical composite drive shafts for helicopter applications.

3. Material used

Stainless steel is the most commonly used material for propeller shaft. Types 303 and 304 are probably worse in this respect, with type 316 being less susceptible, and therefore better suited to salt water use. The 630 type is probably neck-and-neck with K-500 Monel at this stage in technology for the winner in the "best shaft material" race. It costs more than the other stainless types, is stronger, and is less subject to corrosion.

4. Analysis Results for Existing Design

The drive from the transmission to the front and rear axles is accomplished through a propeller shaft and two universal joints. The slip joint is marked with arrows at the spline and the sleeve yoke. Note markings to facilitate proper assembly so the yolks of the universal joints at front and rear of shaft are in the same plane when assembled. The propeller shaft connecting the transfer case with the front axle has the “U” bolt type universal joint at both ends. The rear propeller shaft is equipped with the “U” bolt type joint at the rear where it attaches to the rear axle. The front universal joint is the snap ring type. These universal joints are the Needle Bearing type and are so designed that correct assembly is a very simple matter. when it becomes necessary to replace these parts, the propeller shaft should be removed from the vehicle.

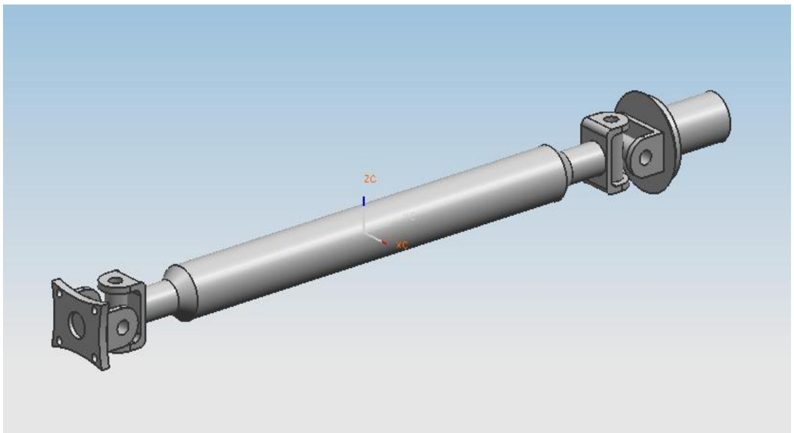

Fig.1 View of universal coupling connected with end

9.1. MODAL ANALYSIS – FREE ENDS:

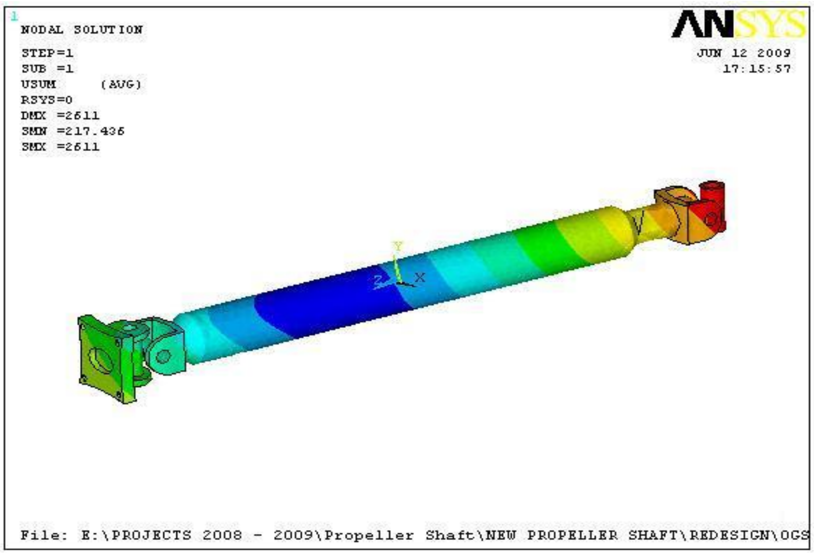

Fig.2 Mode 1 for free end analysis

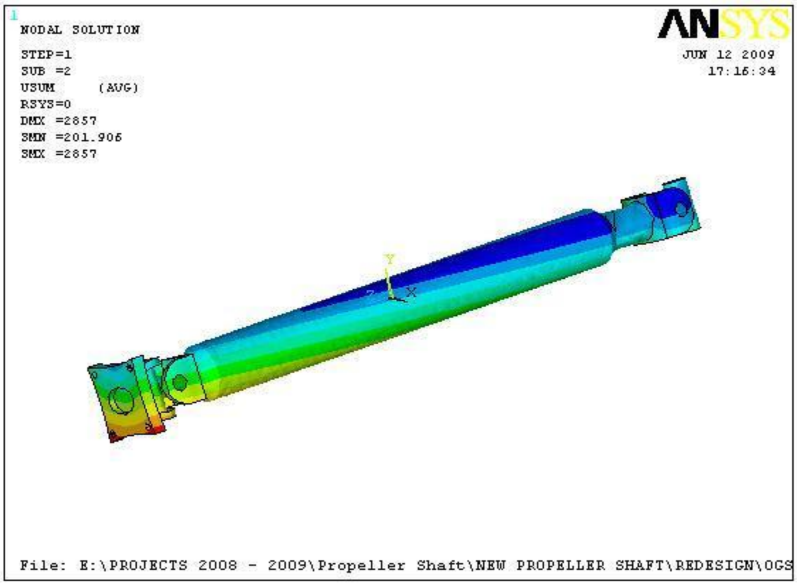

Fig.3Mode 2For Free End Analysis

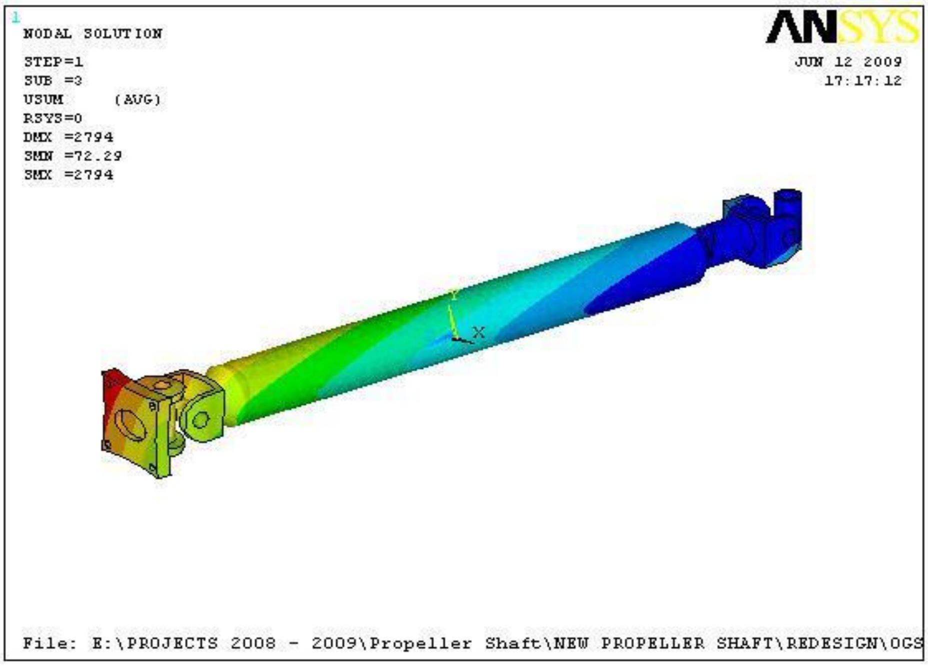

Fig.4 Mode 3 for free end analysis

9.2. MODAL ANALYSIS - DOF ENDS:

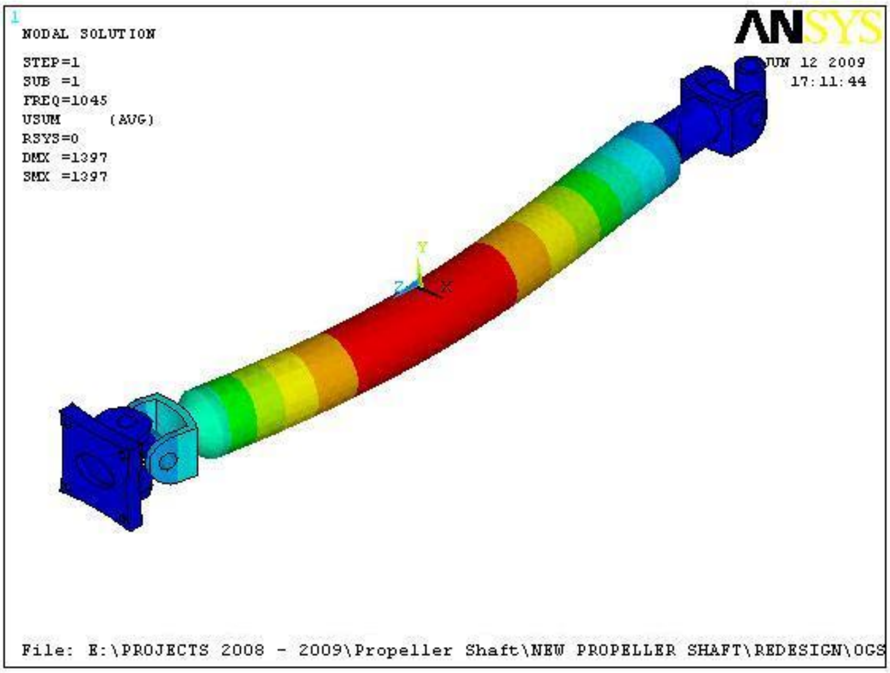

Fig.5 Mode 1 for dof end analysis

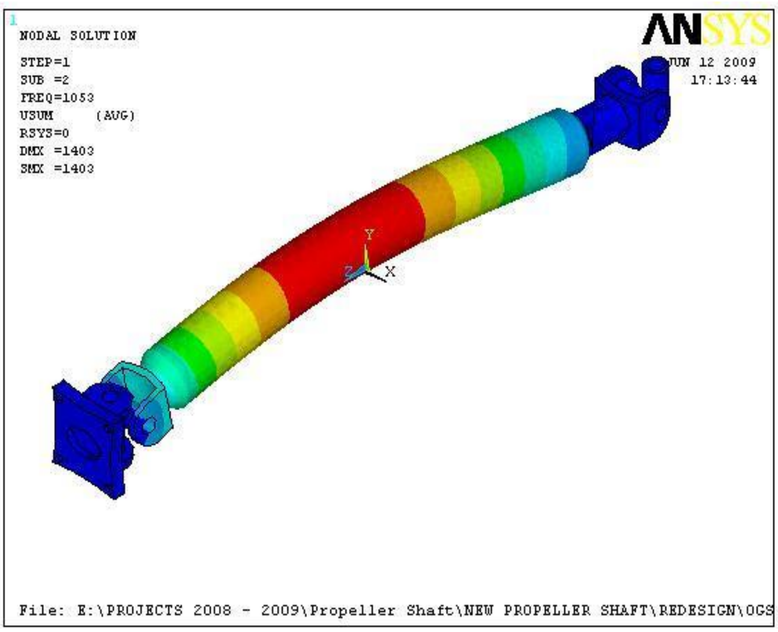

Fig. 6Mode 2 for dof end analysis

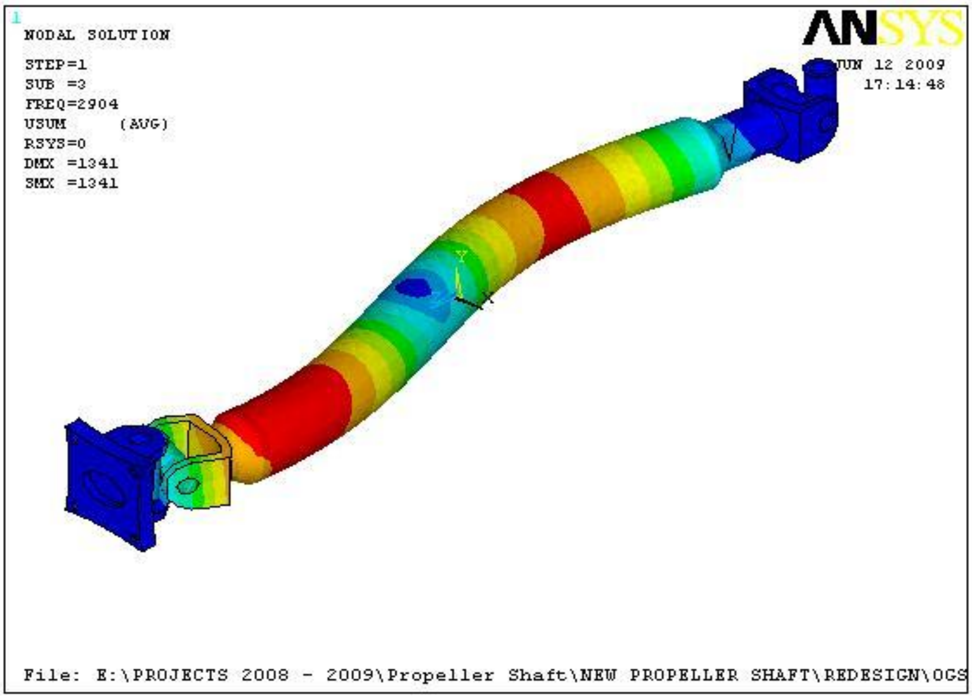

Fig.7Mode 3 for dof end analysis

9.3. TORSIONAL ANALYSIS:

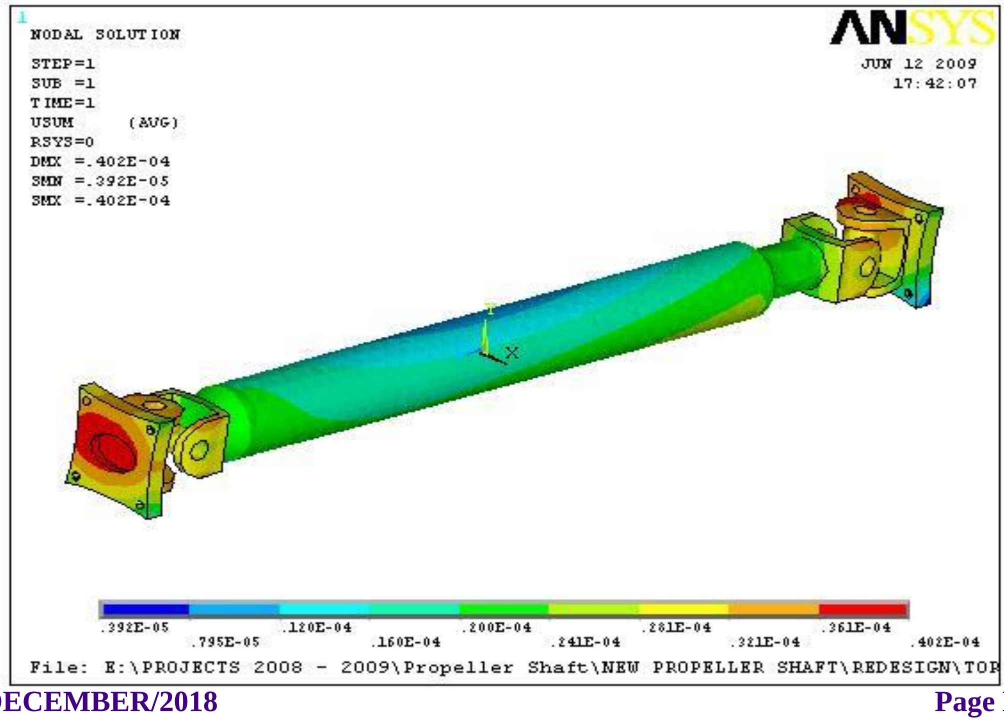

Fig.8Displacement analysis

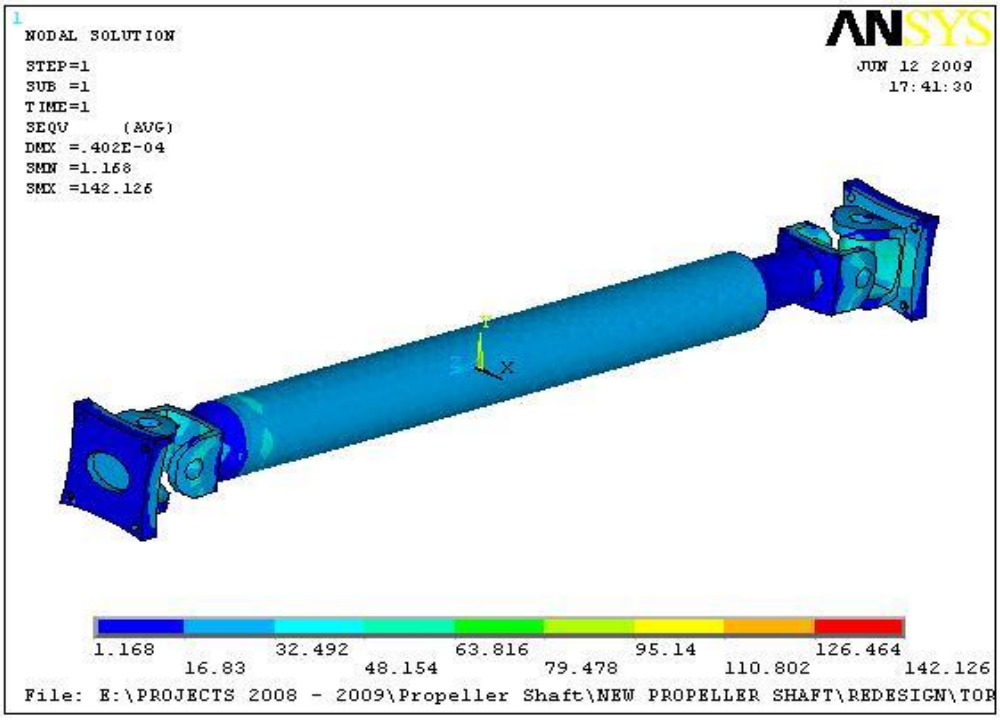

Fig.9Stress analysis

9.4. BUCKLING ANALYSIS:

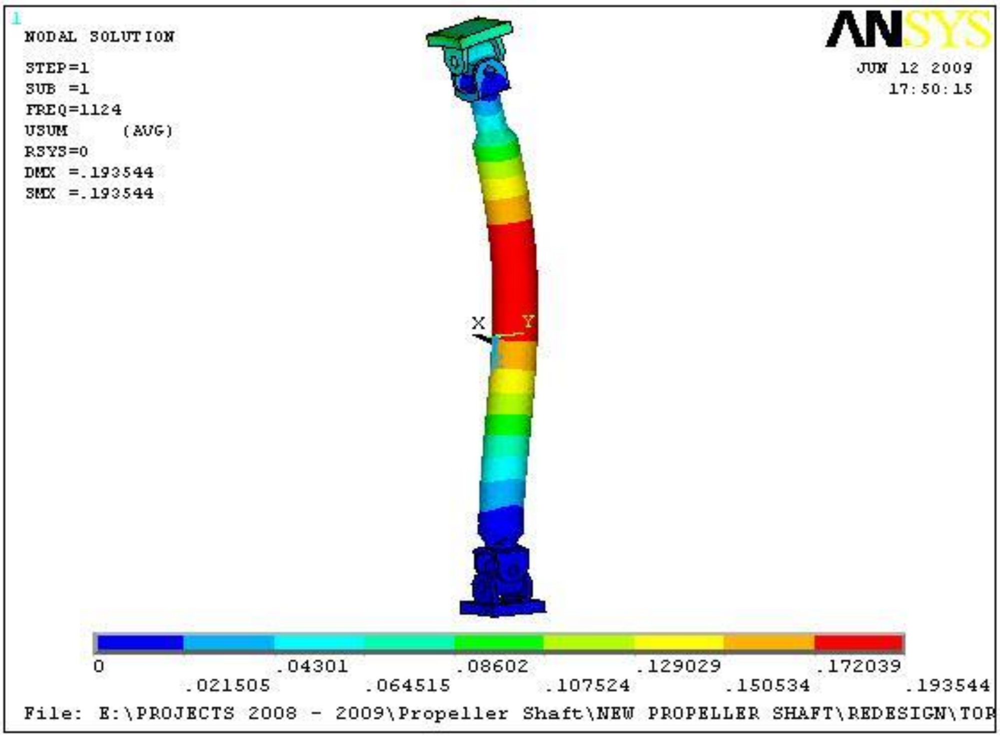

Fig.10Mode 1 for buckling analysis

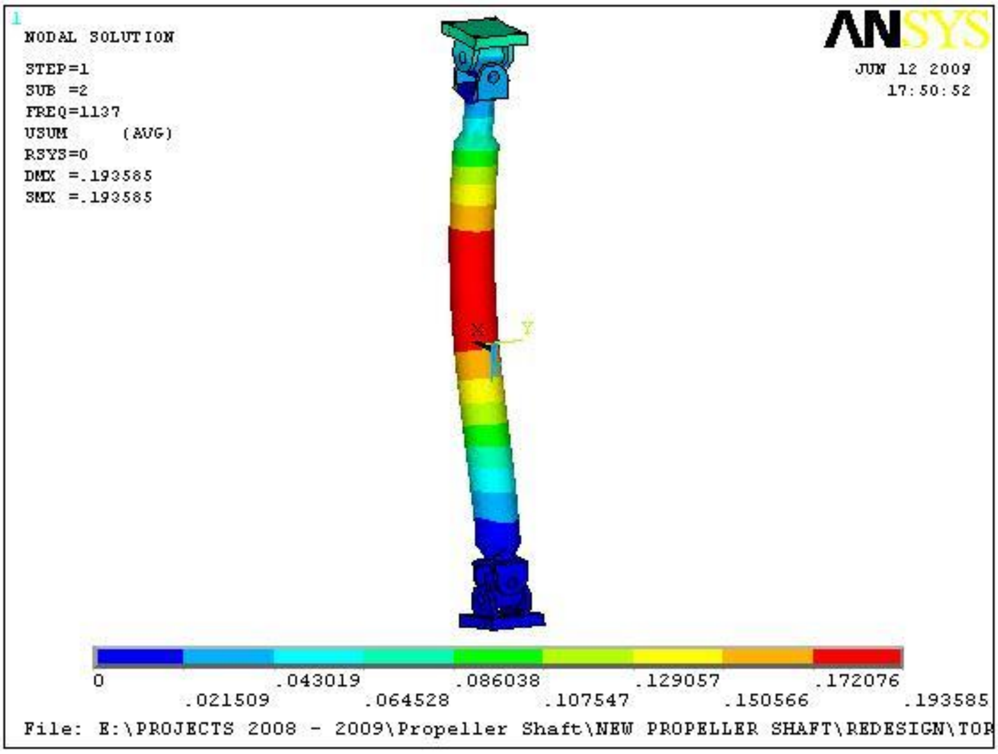

Fig.11Mode 2 for buckling analysis

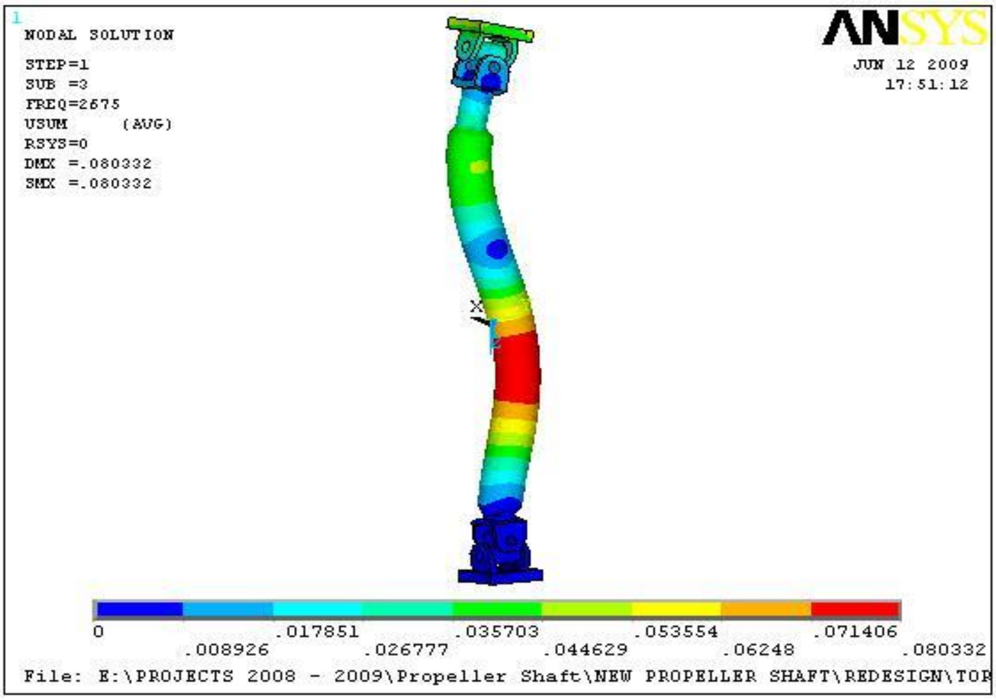

Fig.12 Mode 3 for buckling analysis

Results Comparison

Sl.No	Description	Existing Propeller Shaft	Redesign Propeller Shaft
Vibration Analysis – Modal Analysis			
1	Free Free Modal Analysis	1703 HZ	1700.3 HZ
2	DOF Modal Analysis	1568 HZ 1620 HZ 2550 HZ	1045 HZ 1053 HZ 2903 HZ
Structural Analysis – Angular Velocity			
3	Stress	215.42 N/mm^2	142.126 N/mm^2
	Displacement	0.0167 mm	0.004mm
Buckling Analysis			
4	Buckling Load	908 N 911 N 2413 N	1123 N 1137 N 2675 N
5	Buckling Load Displacement	0.239 mm 0.238 mm 0.141 mm	0.193 mm 0.193 mm 0.08 mm

Table 2 Results Comparison

PRO-E:

Pro-E Wildfire 3 is used for designing the propeller shaft and universal coupling assembly. Existing design of the propeller shaft and universal coupling is initially designed. Design changes are done in the universal coupling and propeller shaft assembly and then redesign is carried out.

ANSYS:

Ansys 8.1 is used for the analysis purpose. Structural analysis is carried out by applying torsion and buckling load. Vibrational analysis is carried out from which natural frequency is found. Results are obtained for the analysis.

9. Conclusion

Propeller shaft near the universal coupling joint loses its strength so that it breaks down frequently due to high frequency vibration. To overcome this problem, the thickness of the propeller shaft is increased and design changes are done in the universal coupling. Vibrational analysis is carried out in the existing design and in the redesign keeping the both ends free and then applying degrees of freedom in the ends. Natural frequency is found out from Vibrational Analysis. Structural analysis is done by applying torsion tothe shaft. Stress and displacement values are calculated. Buckling analysis is also carried out. By carrying out these design changes and analysis work, we find that the redesign offers resistance to the propeller shaft and universal coupling assembly from damage.

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