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Vibrational analysis of pinion shaft for the diagnose of cracks in Heavy loaded vehicle

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Abstract- This paper deals with the identify various methodologies used for the shaft failure analysis and to choose best methodology suitable for the failure analysis of the shaft used in heavy loaded vehicle. From the observation and views of the users of heavy loaded vehicles mainly failure occurs in shaft due to cracks from the vibrations. The present paper is oriented towards design and analysis of cracks for different loading conditions.

Key words: Pinion shaft, Shaft failure, structural stresses, cracks, failure analysis.

1. Introduction

Pinion gear and shaft is the shaft which is use to transmit power for engine to the differential gear box. This shaft having various steps along its geometry because for performing specific function viz. splines to connect it with differential shaft, sleeve for bearing, threads, etc. Since it is a rotational and nonlinear geometric component it is incorporated with various mechanical problems viz.

- Resonance
- Torsional vibration
- Bending under compressive stress
- Vibration instability
- Crack propagation due various stresses.

1.1 Problem Definition

As a Pinion shaft is incorporated with above all mechanical problems among all Torsional vibration and Vibration instability is having major effect in performance and life of pinion shaft. Thus vibrational analysis of stepped shaft plays a vital role in order to:

Transfer maximum power without any mechanical loss.

Maintain proper contact among gears tooth. Maintain proper interference among tooth.

Fig-1: Pinion Shaft

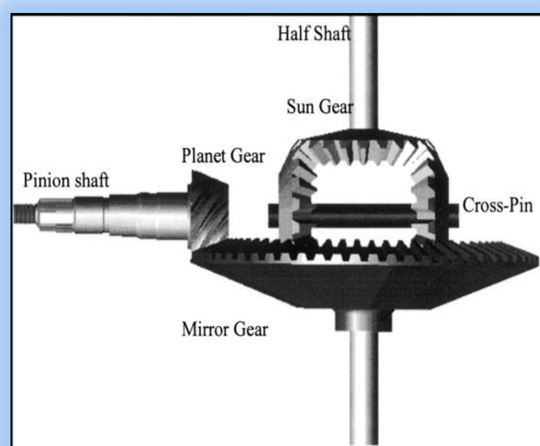


Fig-2: Assembly of Pinion Shaft

2. Structural analysis of shaft:

To analyze the vibrational behavior, bending and shear stress induced in stepped shaft on the application of different loading condition.

Table-1: Analysis approach of shaft

Problem selection (Type of shaft (stepped shaft))
Examination of detailed drawing/manufacturing of stepped shaft
Examination of material of stepped shaft
3D CAD modeling of stepped pinion shaft using solid works 2014
Natural frequency analysis of stepped shaft using ANSYS 14

2.1 Design and Analysis tools of shaft-

Material selection and mechanical properties.

- Dimension data sheet.
- Solid Works 2014 model
- Results estimation by the use of ANSYS 14
- Analytical method to determine the deflection of the stepped shaft.

2.2 Methodology of analysis of shaft-

- In the study of failure analysis of differential pinion shaft mechanical characteristics of the material are obtained first the microstructure and chemical composition are determined.
- Various studies have been made to determine the type and possible reason of the damage.
- Studies carried out to determine the material of the shaft
- Studies carried out to determine the microstructure
- Studies related to the fracture surface.

This paper presents a numerical technique application to analysis of uniform and stepped cracked beam with circular cross section. In this approach in which the FEM component mode synthesis method are used together. The beam is detached into parts from the crack section. These substructure are joined by the flexibility matrix taking into account the interaction force derived by virtue of which fracture mechanics

A new approach to description of the Timoshenko beam free and force vibration by a single equation is proposed. The solution to such an equation is a function of vibration amplitude. The boundary condition corresponding to such a description of the beam vibration is also given. The Timoshenko model is an extension of the Euler-Bernoulli model by taking into account two additional effects: shearing force and rotary motion effect.

MECHANICAL PROPERTIES

MECHANICAL PROPERTIES	DESCRIPTION
MATERIAL	Low alloy carburizing steel of the AISI 8620 type.
YOUNG's MODULUS	2e+011 N/m^2
POISSION's RATIO	0.266
DENSITY	7850 Kg/m^3
YEILD STRENGTH	2.5e+008 N/m^2

MATERIAL PROPERTIES OF AISI 8620

MATERIAL COMPOSITION	PERCENTAGE USED
Carbon	0.18 - 0.23
Chromium	0.4 - 0.6
Manganese	0.7 - 0.9
Molybdenum	0.15 - 0.25
Nickel	0.4 - 0.7
Phosphorus	0.035 max
Silicon	0.15 - 0.35
Sulphur	0.04 max

DETAILED DRAWING OF PINION SHAFT

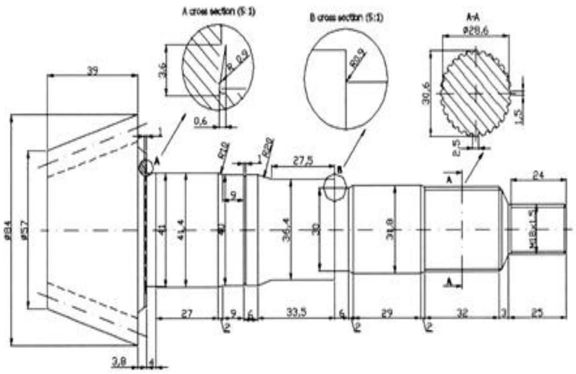
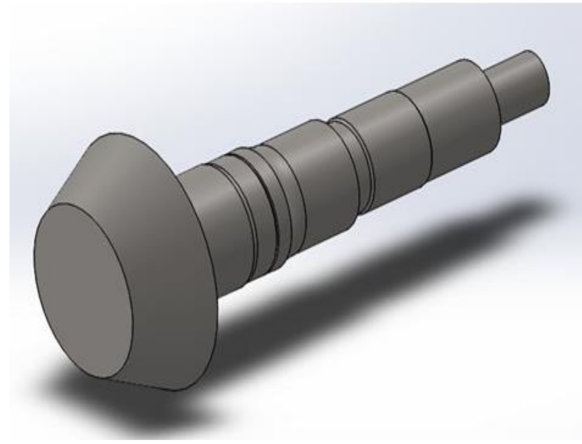
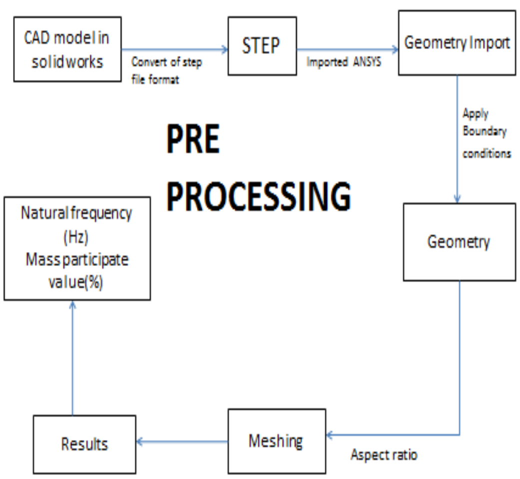


Fig. 3 dimension sheet prepared in AUTO CAD

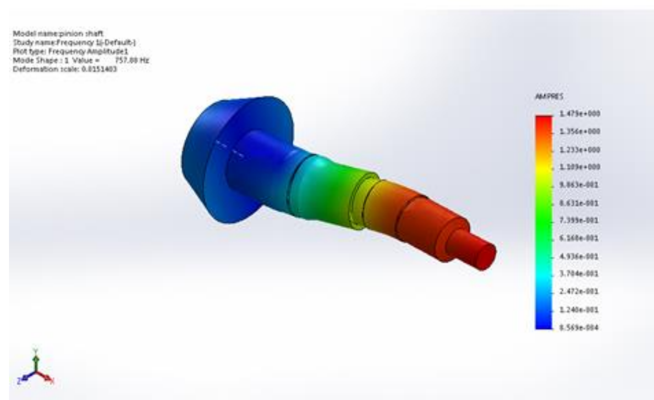
Solid works 2014 model of stepped pinion shaft



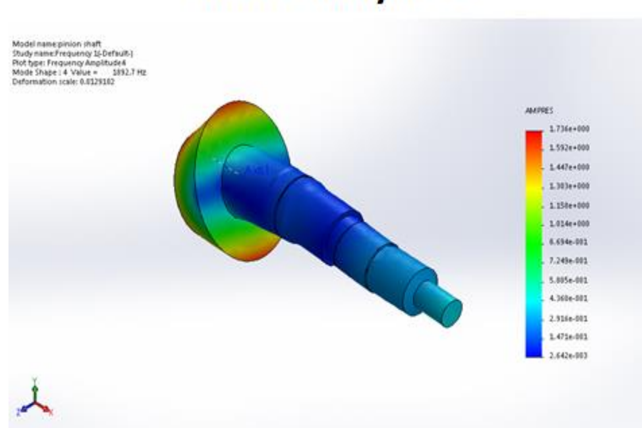
FLOW DIAGRAM



ANSYS Analysis 14



ANSYS Analysis 14

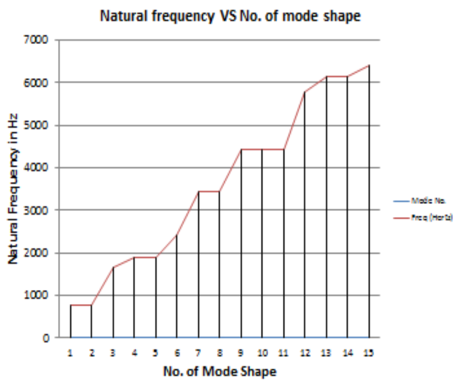


OPERATING CONDITION DATA

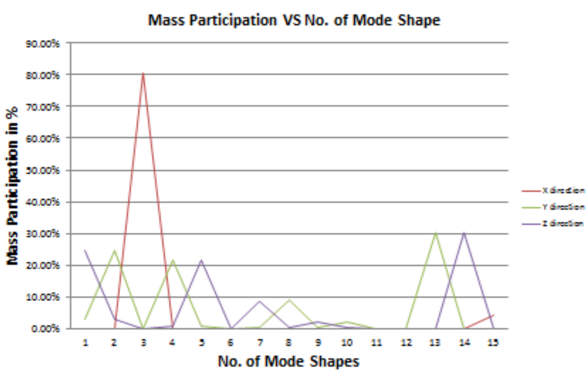
For DAIMLER (diesel vehicle) capacity of 15 people.

DATA	NUMERIC VALUE	UNIT
MAXIMUM ENGINE POWER	90/4000	HP/rpm
MAXIMUM TORQUE	205/1600	Nm/rpm

Results



Results



Conclusions

After the vibrational analysis of shaft ,it conclude that as par natural frequency increases inheavy loaded vehicle shaft the number of mode shape slightly increased and somwhere in the constant natural frequency obtain when mode shape changes so there will be possibility of failure of shaft because of initiation of cracks takes place.

As per mass participation of shaft in mating part mode shape excessively high so amplitude also high and it shows that high stress induced in the mating part, due to this is the reason thechances of crack initiation is possible at the mating part.

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