Impact Factor Value 4.046 **e-ISSN: 2456-3463**
International Journal of Innovations in Engineering and Science, Vol 4, No.10 ,2019
National Level Technical Paper Presentation- PHOENIX-19
Organized by Godavari College of Engineering, Jalgaon-425003
www.ijies.net

A Review Paper on Design and Analysis of Gearbox Casing

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Abstract –*The aim of this Project is to the application of ANSYS software and also FFT analyzer to determine the natural vibration modes and find the free frequency of the Gearbox casing. By finding natural frequency of the Gearbox casing component in order to prevent resonance for gearbox casing. From the result this analysis can show the range of natural frequencies of gearbox casing component with maximum amplitude of it. This is representative of certain key components of complex structures used in Automotive and Production Industries. The mass and stiffness matrices are then determined by exact analytical integration. The results are in close agreement with both experimental and results using analytical approach. Apply ANSYS software and also in FFT analyzer to determine the natural vibration modes and forced harmonic frequency response for gearbox casing. The important elements in vibration analysis are the modeling of the bolted connections between the upper and lower casing and the modeling of the fixture to the support. This analysis is to find the natural frequency and harmonic frequency response of gearbox casing in order to prevent resonance for gearbox casing. From the result, this analysis can show the range of the frequency that is suitable for gearbox casing which can prevent maximum amplitude.*

Keywords: *Fast Fourier transform (FFT), Natural Vibration Modes, Stiffness, Exact Analytical Integration*.

1. INTRODUCTION

Automobiles use rather conventional transmissions, but adopt quite advanced control systems to operate them. In essence the transmissions use a clutch driving a manual gearbox of six or seven forward speeds, which transfers drive via a differential, weight reduction is critical with this component, as it is quite a large percentage of the total weight of the Automobiles and as it is placed so far back in the Automobiles, a recent (2002) mid-field gearbox is known to weigh 30 Kg to 100 Kg fully dressed. The gear cluster sits between the engines and differential in a longitudinal axis, termed as an inboard longitudinal layout, previously the cluster has been placed behind the differential, for easier access at the cost of weight distribution and aerodynamic slimness. Clutches are well known for using carbon-carbon plates, this allows the clutch to withstand heat created from gearshifts and standing starts. The detail development of the friction surfaces and basket, have reduced the size down to a minimum. Clutches used to dictate the crank shaft height of the engine, as there were of a larger radius than the crank stroke, now they are smaller than the crank stroke and further size reduction is irrelevant.

GEAR CASING

Gear cases need to provide the rear structure of the Automobiles as well and allocation for the gearbox. They need to provide mounting points for the rear suspension, impact structure as well and a rigid interface to the rear of the engine. Traditionally cast in aluminium alloys, the detail design of the casing has developed massively over the years. The current format is a large once piece casting from the rear of the engine to the centre line of the differential, with only apertures for the CWP bearing, differential and gear cluster cassette. Smaller castings are required for the differential cap, CWP bearing cover and of course the cassette. Gearbox casing is the shell (metal casing) in which a train of gears is sealed. From the movement of the gear it will produce the vibration to the gearbox casing.

Fig-1 Fig Shows Gearbox casing

2. LITERATURE SURVEY

R. V. Nigade, Prof. T.A.Jadhav,A.M.Bhide "Vibration Analysis of Gearbox Top Cover" [1], in this paper Gearbox casing is a vital component of horizontally split integrally geared centrifugal compressor. Reliability of top cover is directly related to the structural rigidity and structural integrity of compressor. Assuming that the top cover is designed within the mechanical limits of its construction material, one of the most common causes of top cover failure is resonance. The aim of the designer while designing top cover is to have minimum weight and still have sufficient rigidity to avoid resonance. It is imperative; however, that rigorous engineering analysis is applied in the initial design phase to prevent resonance that will result in failure of Gearbox casing.

To meet the objectives of designing a reliable integrally geared centrifugal compressor, Gearbox casing modal analysis is of utmost importance. Numerical modal analysis, usually based on Finite Element Method, is commonly used to determine the vibration characteristics, such as natural frequencies and the associated mode shapes of a structure. This paper addresses finite element analysis and modal testing of Gearbox casing of an integrally geared centrifugal compressor. The goal is to determine, verify and validate the vibration characteristics of the Gearbox casing using both analytical and experimental techniques. However, the effect of addition of rib on the natural frequencies of the Gearbox casing was significant, as compared to increase in the weight of the Gearbox casing.

SnežanaĆirićKostić, MilosavOgnjanović. "The Noise structure of Gear Transmission Units and the Role of Gearbox Walls" [2], in this paper the noise emission of gear units (gearboxes) depends both on the disturbances (gear meshing, bearing operation, etc.) and on the insulating capabilities and modal behaviour of the housing. Natural vibrations of the housing walls can be prevented or intensified depending on design parameters. The mechanism of exciting and emission of transmission noise is defined by carrying out the process of propagation of excitation energy through the structure of power transmitters and by modal testing of the housing. The results of vibration and noise testing in comparison to the results of modal testing give the possibility of identification of noise structure for the chosen gearbox. Comparison and analysis of the results obtained lead to precise determination of the causes of creation of the total spectrum of gear transmission units.

In gear transmission units, sound is generated by excitation in gear teeth meshes and in rolling bearings. Impacts, sliding, rolling, etc. absorb disturbance energy in the elastic structure of machine parts and transmit it through the whole structure. Interior surfaces emit a part of this energy into the surroundings in the form of noise. Another part is converted into heat by damping. Some of the main parts of this process are as follows:Primary sound waves are caused directly in gear meshes and emitted into the interior of the gear unit. These waves penetrate through the housing walls into the surroundings. A part of the wave energy is damped in the gear unit walls.

D. S. Chavan,A.K.Mahale, Dr. A.G.Thakur "Modal Analysis of Power Take Off Gearbox" [3], in this paper"Harvester" machine plays an important role in the harvesting of crops. One of the vehicle system that is involved in the generation of noise and vibrations is the powertrain. Powertrain system includes engine and transmissions. Engine Power Take off (PTO) is one of the main gearbox of powertrain system. It receives power from engine and delivers to other applications of the vehicle. Separator is one of the power output of the gearbox. PTO gearbox of the harvester generates vibrations when engine is running & engaged to the separator. The project scope is to understand the generation of the vibration in PTO gearbox and provide recommendations to reduce vibrations. Modal analysis is a well-established technique which defines the inherent properties of the structure. Modal analysis is used to measure the natural frequency and mode shape pattern. The analysis is done using both analytical and experimental methods. After analysing the data from both methods, the resonance found for one of the component of gearbox. This creates the vibrations in the gearbox. FEA is done for this component with modifications to avoid the resonance. Prototype of the component is made as per modifications suggested and gearbox vibrations are tested. With modified component, the vibrations of the gearbox with separator engaged are reduced to within reasonable limits. **Mr.vijaykumar, Mr.shivaraju, Mr.srikanth, "Vibration Analysis for Gearbox Casing Using Finite Element Analysis", [4]** in this paperapply ANSYS software to determine the natural vibration modes and forced harmonic frequency response for gearbox casing. The important elements in vibration analysis are the modelling of the bolted connections between the upper and lower casing and the modelling of the fixture to the support. This analysis is to find the natural frequency and harmonic frequency response of gearbox casing in order to prevent resonance for gearbox casing Gearbox vibration signals are usually periodic and noisy. Time-frequency domain average technique successfully removes the noise from the signal and captures the dynamics of one period of the signals

Shrenik M. Patil and S. M. Pise, "Modal and Stress Analysis of Differential Gearbox Casing with Optimization", [5] in this paper, The process of casting design in the automotive industry has been significantly refined over the years through the capabilities of advanced computer aided design and engineering tools. One of the significant benefits of these computer aided capabilities is the direct access to CAD geometry data, from which finite element models can be quickly developed. Complex structures can be meshed and analyzed over a relatively short period of time. The application of advanced finite element analyses such as structural modification and optimization are often used to reduce component complexity, weight and subsequently cost. Because the level of model complexity can be high, the opportunity for error can also be high. For this reason, some form of model verification is needed before design decisions made in the FEA environment can implemented in production with high confidence. Dynamic correlation, comparison of mode shapes and natural frequencies, is a robust tool for evaluating the accuracy of a finite element model. The objective of the project is to analyze differential gearbox casing of pick up van vehicle for modal and stress analysis. The theoretical modal analysis needs to be validated with experimental results from Fourier frequency transformer analysis. The main motivation behind the work is to go for a complete FEA [1] of casing rather than empirical formulae and iterative procedures.**Yuan H. Guan and Mingfeng Li "Comparative Analysis of Actuator Concepts for Active Gear Pair Vibration Control", [6],** In Their Paper, Four actuation concepts for the active suppression of gearbox housing mesh frequency vibrations due to transmission error excitation from the gear pair system are modelled and compared by computing the required actuation forces and amplifier power spectra. The proposed designs studied consist of (1) active inertial actuators positioned tangentially on the gear body to produce a pair of reactive force and moment, (2) semi-active gear–shaft torsional coupling to provide tuned vibration isolation and suppression, (3) active bearing vibration control to reduce vibration transmissibility, and (4) active shaft transverse vibration control to suppress/tune gearbox casing or shaft response.

L.H. Wu, Y. Lu "Free vibration analysis of rectangular plates with internal columns and uniform elastic edge supports by pb-2 Ritz method", [7] in paper, Free vibration analysis of rectangular plates with internal columns and elastic edge supports is presented using the powerful pb-2 Ritz method. Reddy's third order shear deformation plate theory is employed. The versatile pb-2 Ritz functions defined by the product of a two-dimensional polynomial and a basic function are taken as the admissible functions. Substituting these displacement functions into the energy functional and minimizing the total energy by differentiation, leads to a typical eigenvalue problem, which is solved by a standard eigenvalue solver.

Myung-Soo Choi and Jung-Hwan Byun, "Sensitivity analysis for free vibration of rectangular plate", [8] This paper presents an effective sensitivity analysis algorithm for free vibration of a rectangular plate structure by using the finite element-transfer stiffness coefficient method (FE-TSCM). The basic concept of FE-TSCM combines both the modeling technique of the finite element method (FEM) and the transfer technique of the transfer stiffness coefficient method (TSCM) in order to benefit from the merits of both FEM and TSCM in the dynamic analysis of a structure. From the results computing the sensitivities of eigenvalues and eigenvectors for a simply supported rectangular plate structure by FE-TSCM and Fox's method, we can confirm that FE-TSCM has merits from the viewpoint of computational time and memory in sensitivity analysis for free vibration of the rectangular plate structure with a large number of degrees-of-freedom

2.1 Problem Statement

The frequency & Phase response of Casing which are obtain by the gears in gearbox due to rotation of gears. The rotation and weight of gears leads to vibration. If the frequency matches with natural frequency of gear box casing then amplitude of frequency increases due to resonance of frequencies. If this happened it leads to the failure of the gearbox. By using vibrational stiffeners the vibrational frequency is minimized and avoidance of failure of gearbox and gearbox casing.

2.2 Objective

- Understanding the generation of the vibration of synchromesh gearbox.
- Correlate the theoretical and experimental results.
- Recommend and apply solutions to reduce the vibration level by 15-20% of current levels.
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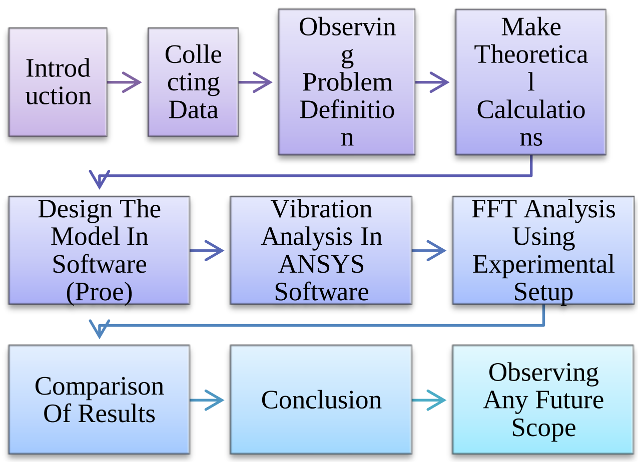
3. METHODOLOGY



3.1 System Software

Pro-Engineer software

Getting Started with Pro/ENGINEER Wildfire is a tutorial-based introduction to creating parts, assemblies and drawings in Pro/ENGINEER. If you follow the complete series of procedures, you will learn how Pro/ENGINEER passes 3D design information to and from every design stage, from solid part creation, to part assembly, to the output of mechanical drawings.

3.2 Gear Mesh Frequency

The most powerful weapon in analysing gear noise is to determine the spectral character. The first step in determining the spectral character is to calculate the fundamental gear mesh frequency. Since each gear meshes once per revolution, the fundamental gear mesh frequency F1 is the product of shaft rotation and the number of gear teeth

Gear mesh frequency (F) = k * (N/60) Hz

Table No.1 Gear Reduction Ratio in TATA ACE

Gear Pair	Meshing Shaft	No. of Teeth	Reduction Ratio	Overall Reduction
Constant Mesh	C to D	37:24	1.54 (C)	-
First	M to C	41:12	3.41 (F)	5.27 (C x F)
Second	M to C	38:22	1.72(S)	2.66 (C x S)
Third	M to C	29:32	0.91(T)	1.40 (C x T)
Fourth	-	-	Direct Drive	1

3.3 CALCULATION OF SPEEDS FOR GEAR MESH FREQUENCY

First Gear Speed Range

Shaft → 1 → from 600 rpm to 1000 rpm

$N_1 * T_1 = N_2 * T_2$

$(600 – 1000) *24 = 37*N_2$

$N_2 = (389 – 649)$ rpm → shaft 2

$N_2 * T_2 = N_a * T_a$

$(389 – 649)*12 = N_a*41$

$N_a = (114 – 190)$ rpm → speed in first gear

Gear meshes frequencies of the corresponding gears:

First gear

$F_1 = 41*(114 – 190)/60 =$ **(78 – 130) Hz**

Second Gear

$F_2 = 38*(300 – 563)/60 =$ **(190 – 357) Hz**

Third Gear

$F_3 = 32*(705 – 1352)/60 =$ **(376 – 721) Hz**

Forth Gear

$F_4 = 37*(1297 – 2076)/60 =$ **(800-1280) Hz**

Power = 8.5 HP

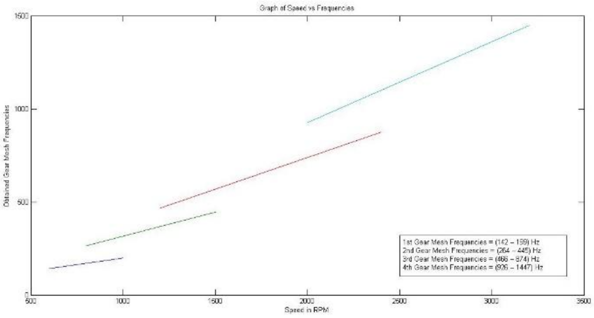
Speed = 3200 rpm

ASSUMPTIONS:

1. Considering addition of frequency generated by engine rotation is
2. F = (N/60) = 3200/60 = 53.333333 Hz

3. Considering the increase in frequency by 5% to 12% due to stiffness of Bearing mounted on the casing for holding Shaft and allowing to rotate. (Here average percentage are considered which is 8.5%)

1st Gear Mesh Frequencies = **(142 – 199) Hz**
2nd Gear Mesh Frequencies = **(264 – 445) Hz**
3rd Gear Mesh Frequencies = **(466 – 874) Hz**
4th Gear Mesh Frequencies = **(926 – 1447) Hz**



Graph-1 Graph of Speed vs. Gear Mesh Frequency

4. CONCLUSION

The present investigation based on the theoretical Analysis, FEA Analysis and experimental analysis draws the following expectations.

- Inputs for FEA and FFT are excitation of casing which leads to vibration and outputs are natural frequency for different modes of vibration.
- The bearing reaction are not considered while solving the problem on gear mesh frequency is matter here.
- We can use MATLAB to calculate and plot gear mesh frequencies in given speed range.
- By changing the wall thickness and rib height of the gearbox casing the resonance problem will be solved

Here a new approach can be suggested which is based on the combination of both ANSYS and FFT, in which natural frequency obtained in ANSYS and FFT can be compared and use to minimise resonance of part due to vibration and solving the problems regarding vibration

REFERENCES

[1] *R. V. Nigade, T. A. Jadhav, Vibration Analysis of Gearbox Top Cover, International Journal of Innovations in Engineering and Technology (IJIET), 1(4), 2012, 26-34.*

[2] *SnezanaCiricKostic and MilosavOgnjanovic, the Noise Structure of Gear Transmission Units and the Role of Gearbox Walls, FME Transactions 35, 2007, 105-112.*

[3] *D. S. Chavan and A. K. Mahale, Modal Analysis of Power Take Off Gearbox, International Journal of Emerging Technology and Advanced Engineering, 3(1), 2013, 70-76.*

[4] *Vijaykumar, shivaraju and shrikanth, Vibration Analysis for Gearbox Casing Using Finite Element Analysis, The International Journal Of Engineering And Science (IJES), 3(2), 2014, 18-36.*

[5] *Shernik M. Patil and S. M. Pise, Modal and Stress Analysis of Differential Gearbox Casing with Optimization, Int. Journal of Engineering Research and Applications, 3(6), 2013, 188-193.*

[6] *Yuan H. Guan et al, Comparative analysis of actuator concepts for active gear pair vibration control, Journal of Sound and Vibration 269, 2004, 273–294.*

[7] *L. H. Wu and Y. Lu, Free vibration analysis of rectangular plates with internal columns and uniform elastic edge supports by pb-2 Ritz method, International Journal of Mechanical Sciences, 53, 2011, 494–504.*

[8] *Myung-Soo Choi and Jung-Hwan Byun, Sensitivity analysis for free vibration of rectangular plate, Journal of Sound and Vibration, 332, 2013, 1610–1625.*

[9] *Y. Kerboua et al, Vibration analysis of rectangular plates coupled with fluid, Applied Mathematical Modelling, 32, 2008, 2570–2586.*

WEBSITES:

https://www.irjet.net/archives/V3/i11/IRJET-V3I11263.pdf
http://www.ijera.com/papers/Vol3_issue6/AF36188193.pdf
https://www.researchgate.net/publication/267860872_A_study_of_Vibration_Analysis_for_Gearbox_Casing_Using_Finite_Element_Analysis
https://en.wikipedia.org/wiki/Tata_Ace