International Journal of Scientific Research and Management Studies (IJSRMS)
ISSN: 23493771 **Volume 1 Issue 9, pg: 289-296**

VIBRATION ANALYSIS USING FINITE ELEMENT METHODOLOGY TO EVALUATE THE RESPONSE OF GEAR HOUSING OF AN AUTOMOTIVE TO THE MATERIAL AND ITS MASS PROPERTIES

Parag V. Bute [1], R. J. Patil [2], Swapnil S. Kulkarni[3]
[1]Student, M.E (Mechanical Design Engineering), [2]Principal
Dr.D.Y.Patil Institute of Engineering and Technology, Ambi-Pune Maharashtra, India
[3]Director, Able Technologies (I) Pvt. Ltd., Pune, Maharashtra

ABSTRACT

The gear housing is the casing that surrounds the gear box. The function of gear box casing is to protect and provide a platform for gear transmission. It also provides supports for moving parts and protection from outside environment. It also acts as fluid tight container which holds the lubricant that bathes the gear box parts. Parts such as gears, shafts, pinion shafts, bearings, oil seals etc. These make the gear box housing an essential component in engine of automobile. The gear housing is in the vicinity of the gear box and engine. Hence will get subjected to vibrations so it becomes necessary to evaluate the response of gear housing to such vibrations and also to find out there natural frequency. This can be an important tool while designing the gear housing free from fatigue failures caused by the resonance. The design of the gear housing should incorporate a methodology for dealing with factors causing vibrations and to promote scientific means to minimize the effects of resonance. This vibration analysis is done by using finite element method as a computational technique and validating it by physical experimentation using FFT analyzer.

KEYWORDS:-*Gear Housing, Natural Frequency, Finite element method, FFT analyzer.*

I. INTRODUCTION

Gears are used to increase or decrease the input speed. These gears are enclosed in rigid closed housing called as casing. This casing supports the shaft, hold the lubricant inside and protect the gears from dust and moisture. Also it provides the necessary cooling surface to dissipate the heat generated during operation. The gear box is widely used for variation of speeds in automobile. A gear box housing in general consists of two halves-the upper half and the lower half. The plane of separation of the two halves also normally contains the axes of the shafts and bearings. Such arrangement facilitates easy mounting and dismantling of shafts and bearings. Themating surfaces of the two halves are properly machined and suitable gaskets are provided between them to secure tightness against entry of dust and leakage of oil. The upper and the lower casings are then bolted together and are also provided with dowel pins for proper alignment. Oil seals are fitted inside the grooves on the bearing covers through which the shafts project out. These serve the dual purpose of preventing the gear oil from leaking out and extraneous contaminants from entering the gear box. Felt sealing rings are also used for the purpose. The radial oil seals, which are usually fitted to the gear box bearing covers, are of specifications as per IS: 5129-1969.Bolt holes are bored on the bottom flange of the lower casing for securing the gear box to its support or to the civil foundations.

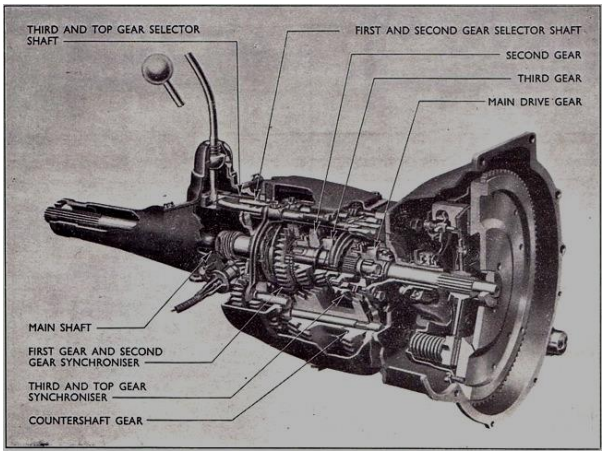


Fig: 1. A Cross Sectional view of gear box housing

II. LITERATURE REVIEW

[1] Mr.Vijaykumar, Mr.Shivaraju, et al

In this paper author has discussed about the vibration analysis of gear-box using FEA. An ANSYS Software is used to find out the natural frequency and harmonic frequency of gear-box casing resulting into the determination of range of frequencies to prevent resonance. The modal analysis is done to find Natural Frequency and Harmonic Frequency. The results of both are compared and vibration analysis is done on the gear-box. The fault detection and diagnosis is done from above vibration analysis. The author has also used advanced signal processing techniques for the vibration analysis.

[2] E. Tomeh, et al

In this paper the author has outlined the importance of using technical diagnostics methods for the measurement of vibrations of gear-box of the car. The measured vibrations of the gear-box can be used as a predictive maintenance tool which directly minimizes the maintenance activities and also improves the performance of the car in the most efficient way. Since the noise created by a car has a negative effect on its vicinity which includes car driver also. This disturbance can affect the driver's concentration during driving resulting into the safety issues for road traffic. Also the De-assembling the gear-box often deteriorates its technical condition which results in the vibration and noise. There is no use of replacing just a damaged part unless and until the cause of vibration is not eliminated.

[3] V. B. Maner, M.M. Mirza, ShrikantPawar, Design Analysis and Optimization for Foot Casing of Gear-Box. Proceedings of 3rd IRF International Conference, 10th May-2014, Goa, India, ISBN: 978-93-84209-15-5.

In this paper the author has basically focused on the design optimization of gear- box foot casing. Casing is an important component of gear-box as it provides support to bearings, shafts and gear loadings. It is basically a metallic case made by casting. The author has done design optimization of gear-box foot casing at Top Gear Transmission Industry situated at Satara, India. In this industry foot casings are made up of cast iron castings having a weight around 72 kg. This weight is 32% of entire gear-box assembly which is considerably high and needs to be optimized. So as to minimize the material and cost consumption. The author has generated the 3D model in PRO-E software; static analysis is done on ANSYS software. The design optimization is based on ANSYS results. The main focus is to optimize the foot casing and to find out effective and efficient design of gear-box with respect to both cost and durability.

[4] N. Sawalhi, R.B. Randall, et al

In this paper the author has discussed about the new approach of calculating the gear mesh frequencies and monitoring these frequencies with their sidebands. Since the correct diagnosis of faulty components in rotating machines needs detail knowledge of the characteristics of system and the identification of their frequencies. In old gear-boxes the information required to calculate gear mesh frequencies and their sidebands is not available easily. So this new approach takes a signal from gear-box of wind turbine. The wind turbine is used due to the variation of speed.

The author had focused a blind determination of number of teeth of wind turbine in a variable speed situation. The four stage approach has been presented in which 1st stage describes acceleration signal measured on gear-box was down sampled to allow the analysis of larger records. In 2nd stage spectrogram was utilized to check the speed variations and to decide where speed variation is small. In the 3rd stage order tracking is implemented to remove speed variations or fluctuations as from signal resulting into high accuracy analysis of harmonic cursors. These harmonic cursors were used to track different families and sidebands around the meshing frequencies which help in discovering the teeth's of each gear.

[5] Abdulla H EI Sherif, Effective Machinery Fault Diagnosis Avoids Unnecessary Gearbox Maintenance (Case Study). R.B.K.N. Rao et al. (eds.), COMADEM 89 International Kogan Page Ltd. 1989.

The author who is Senior Engineer Rotating Machinery at Abu Dhabi Marine Operating Company has focused on the fault diagnosis and identification technique by illustrating the problem which was experienced during the commissioning of gas turbine driven crude oil loading pump. While commissioning these pumps the gear box has experienced exercise vibrations causing the concern over the capability of pump and reliability of the gearbox which is critical equipment. Now the ability to detect the machinery problems with dismantling the machines requires effective and comprehensive fault diagnosis. The significant tool which will overcome this situation was vibration analysis. As it prevents catastrophic failures, minimum equipment down time and unnecessary shutdowns, repairs. Now by using vibration analysis technique the cause of the problem was detected which indeed was improper vibration sensor's holder design and installation. The author had also highlighted the efforts involved in its analysis and identification. The corrective actions that are taken effectively to resolve with minimum cost and downtime.

[6]Mitchell lebold, Katherine McClintic, et al

The author had emphasis on how there are many ways to process vibration data for conditional based maintenance purpose. But the interpretation and correlation of this data is very much difficult even for the experience persons. Many methods have been developed over the years but the details associated with each method are not clear. In various methods the terms like residual signals are used for different meanings. The author has tried to define and standardize these terms and also correlate them. The above paper is focused on methods that are used for detection of gear faults. The methods are categorized into five different processing sections depending upon their processing needs.

The author has also explained feature extraction technique details such as RMS, Delta RMS, Kurtosis, Crest Factor, Enveloping and Demodulation.In RMS technique time analysis feature which is a measure of power content in vibration signature. This feature is a good tracker to noise level. But it is only limited to only detecting major imbalanced rotating systems. Delta RMS is basically the difference between the current RMS and previous RMS.

[7] S. Chen, J. Tang, C. Zhou, Z. Hu, Modal Whirling Analysis of Coupled Lateral And Torsional Vibration Of Herringbone Gear. Springer-Verlag Berlin Heidelberg 2013.

In the above paper the author has done the modal and whirling analysis of Double Helical Gear also known as Herringbone Gear. In this the author has investigated the effect of damping, eccentric mass and time varying mesh stiffness of gear pair of herringbone gear. The coupled lateral and torsional motions are of very much important for the herringbone gear in high speed applications. At high speed the gyroscopic phenomenon occurs in herringbone gear which cannot be ignored. The author has proposed the analytical model for coupled lateral and torsional motions of herringbone gear having a thin rib and web. The natural frequencies, synchronous whirling speed, critical speed, transient behavior has been calculated numerically. The results were shown in Campbell diagram shows that critical speed is slightly affected due to damping whereas eccentric mass has a significant effect on critical speed. The transient dynamic analysis is also done which shows that high frequency has a predominant effect independent of stiffness. The paper also throws light on paying attention to critical speed relative to mesh frequency foe high speed application. The main objective of this paper is to reveal the modal vibration structure of high speed herringbone gear having a gyroscopic effect. In this first the model of herringbone gear having equivalent mesh stiffness and thin rim and web based on finite element method is analyzed. Then a dynamic model having five degrees of freedom is analyzed. Whirling motion and critical speed of each model is analyzes numerically.

[8] I.A. Bednyi, et al
In this paper the author has used the model of forced vibrations in planetary gear based on finite element method. This model was further used to solve static and dynamic problems for mechanism of planetary gearbox. The planetary gear is used widely. Since they enables to decrease the size and weight of the gear box. The author has also stated the method of constructing a mathematical model of forced vibration for the epicycle gear and synchronizing this with the remaining part of the gear box using the dynamic stiffness and finite element method. Thus it helps in generating a mathematical model easily in a computer mode.
[9] Mr. BhavinGajjar, et al
In this paper the author has use the FEA method for the analysis of static and dynamic loads on gear box housing. The author has done the force analysis for helical Gear. The author has explained the importance of force analysis for designing the gear box housing. The force analysis for structural loads and gearbox stress distribution is done by using ANSYS.
[10] Shrenik M. Patil, Prof. S.M. Pise, et al
The author has summarized modal and stress analysis of differential gearbox casing with optimization. The gear box casing used here is of pick up van vehicle. The casting design processes have been significantly improved over the years by addition of advanced computer aided design and engineering tools. This enables one to get direct access to CAD geometry data from which models foe FEA can be developed quickly. Complex structures can be meshed and analyzed over a relatively short time. The advance FEA reduces the component complexity which indeed reduces the opportunity of error. The main objective of the paper is to analyze the differential gear box and to go for a complete FEA of casing rather than empirical formulae and iterative procedures.
[11] P.D. Patel, D.S. Shah, et al
The author had presented steady state thermal stress analysis of gear box casing using FEM. In this paper the thermal stress are analyzed on the gearbox casing which are formed due to frictional heat, speed enhancement. The tempeture field has been coupled to the 3- dimensional structure model using FEM. The study of equivalent von misses stresses on inner and outer walls of gearbox casing for the convection effect between the walls and circulating oil has done using ANSYS software. The main objective was to check whether the element or collection of element can safely withstand the thermal load. The maximum equivalent stress of the upper and lower casing model is found out and also the maximum displacement of casing which is very much important tool for optimum designs.
[12] M.Davis, Y.S. Mohammed, et al
The author has analyzed the design for static and dynamic loading for gear housing using FEA. The modern trend of using more and more user friendly mechanical power transmission products has given rise to a product such as high-hourse power, right angle, shaft mounted drive which leads to minimum installation effort. Commonly known as alignment free type drive which results quicker mounting, more cost effectiveness and less installation expertise. The author has done static and dynamic analysis on the above alignment free drive by using FEA for better design optimization. FEA was done on C.I. housing to find out a potential problem before the actual production begins. Previously the failure of gear reducer housing was directly related to static and dynamic loadings. High stresses were arising due to large size of components, improper gear meshing and impact and also from vibrations coming out from the system. The FEA has shown the areas where failure could happen. These areas were looked more closely and redesigned it to withstand the stresses that induced.
[13] Y. Shivraj Narayan, K. Karumanchi, et al
This paper deals with the modeling of the side engine cover of gear box casing of mini truck. The gear box casing is used here is made up of main casing, side casing and side differential cover. The modeling was done in Pro/E software of version wildfire2.0 and manufacturing of complicated shapes and parts. The author has also explained the step by step procedure to model the component in Pro/E by explaining the tools such as Extrude, Shell, Revolve, Sweep, Blend, Advanced and surface modeling. Also core cavity required for manufacturing of side engine cover of gear box casing was also prepared by manufacturing module of Pro/E. a prototype model has been manufactured and assembled in mini truck successfully.
[14] Syed R UL Haque, Prof. Dongyan Shi, et al.

In this paper static analysis of gearbox casing done in two different models global/coarse and sub model of Ansys. It was statically analyzed using simulation software here in the paper. The author had focused over the static analysis of gear box casing hook. Since it plays an important role during lifting off and fixing the gearbox. The static analysis was done by the application of sub modeling method in ANSYS. It utilizes two separate modes. i) Global ii) Sub model. The global represents the entire structure was used to transform global loads to local deformation. The sub model represents local geometric details with appropriate density. The static analysis of gear box casing and sub model has facilitated in the development of optimum design of gear box making the calculations easy and efficient.

[15] Fujin Y Yongxiang, Daowen Sn, Wenquan Shen, et al

In this paper the author had reduce the noise and vibration of automobile transmission system by the structural optimization for better performance. Modal analysis of gearbox was formulated in 3-D software like Pro/E together with FEM. The modal test was also done and the results were compared. By doing this the author has found out the natural frequencies of gearbox body, vibration sensitive parts of gearbox. Those would play an important role in design of structural optimization and then will consciously change the resonance frequency to avoid the structural problem.

III. PROBLEM DEFINITION

A natural frequency, exemplified by resonance is the characteristics of the part or sub-assemblies in a given product. This becomes noteworthy while evaluating performances of applications where human comfort or longevity of the component life has a prominence in the function. Automobiles for example, are subjected to vibrations in turn caused by the engine. The components making up the sub-assemblies need to be evaluated for this phenomenon. The design of the component should incorporate a methodology for dealing with factors causing unacceptable levels of vibration or to promote any scientific means of problem solving that would minimizing the harmful effects of resonance.

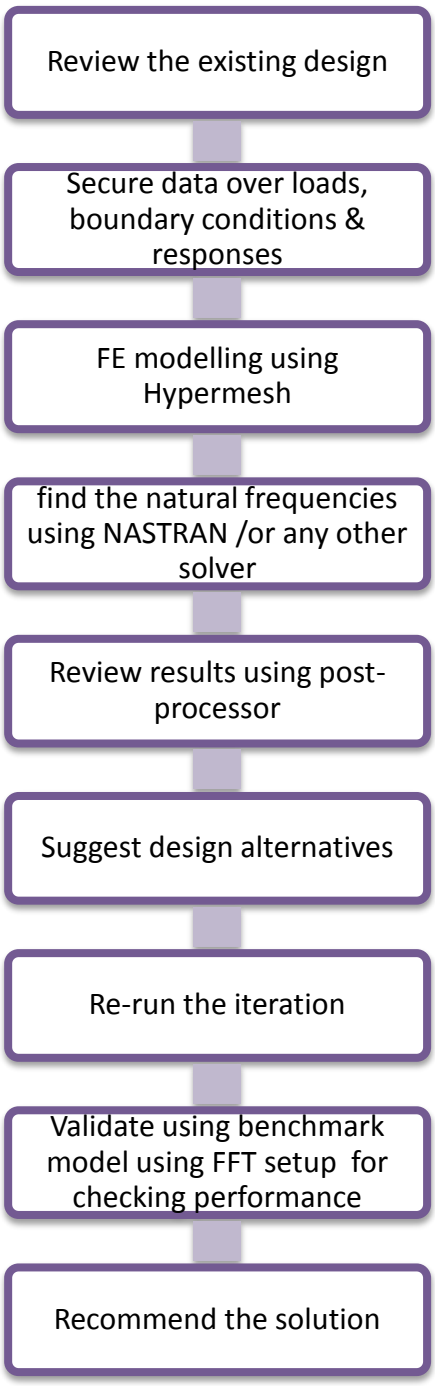
IV. SCOPE

The scope would involve activities starting with securing CAD data for this work from the concerned Company. The material, specs and the resonating frequency or frequencies under consideration, if any, shall be documented for study and analysis further. Mathematical model to be built for preliminary investigation into the problem. Simulation using CAE software to be deployed for seeking computational solution. For alternative methodology, experimentation using a physical setup shall be engaged for trials and testing. FFT analyzer or suitable instrument to be used for recording the data towards `vibration' measurement. Recommendation to follow upon review and appraisal.

V. OBJECTIVES

- Identify and secure Engineering data over the problem area.
- Define problem and set out a plan in the scope of F.E. Modeling.
- Perform Modal Analysis using Mathematical and/or computational techniques.
- Analyze the results to identify areas of improvement through change in the significant Design parameter/s.
- Iterate and refine results. Validate the results for benchmark (existing) model for arriving at recommendation.

VI. METHODOLOGY: (PROCESS FLOW CHART)



VII. EXPERIMENTATION & VALIDATION

Experimentation would be completed using FFT setup. An FFT spectrum analyzer works in an entirely different way. The input signal is digitized at a high sampling rate, similar to a digitizing oscilloscope. The resulting digital time record is then mathematically transformed into a frequency spectrum using an algorithm known as the Fast Fourier Transform or FFT. The FFT is simply a clever set of operations which implements Fourier's basic theorem. The resulting spectrum shows the

frequency components of the input signal. The advantage of this technique is its speed. The entire spectrum takes only 4 ms to measure.
For validation purpose the Natural frequencies obtained from computational method and experimental method would be compare.

VIII. CONCLUSION

In the present thesis more emphasis will be on vibration analysis of gear housing of an automobile by determining natural frequencies, mode shapes with the help of modal analysis. Furthermore frequency response will be measured at different excitations and the response will be analyzed in FRA. Also FEA method is used to study the dynamic properties such as mass, stiffness of gear housing under consideration.

REFERENCES

[1] Mr.Vijaykumar, Mr.Shivaraju, Mr.Srikanth , Vibration Analysis for Gear-Box Causing Using Finite Element Analysis. The International Journal Of Engineering And Science (IJES). Volume- 3, Issue-2, Pages 18-36. (2014)ISSN (e):2319-1813 ISSN (p): 2319-1805.
[2] E. Tomeh, Identify The Sources Of Vibration And Noise On Cars Gear-Box By Spectral Analysis. Technical University Of Liberec, Czech Republic. Springer International Publishing Switzerland 2014.
[3] V. B. Maner, M.M. Mirza, ShrikantPawar, Design Analysis And Optimization For Foot Casing Of Gear-Box. Proceedings of 3rd IRF International Conference, 10th May-2014, Goa, India, ISBN: 978-93-84209-15-5.
[4] N. Sawalhi, R.B. Randall, Gear Parameter Identification In Wind Turbines Using Diagnostic Analysis Of Gear-Box Vibration Signals. Springer – Verlag Berlin Heidelberg 2014.
[5] Abdulla H EI Sherif, Effective Machinery Fault Diagnosis Avoids Unnecessary Gearbox Maintenance (Case Study). R.B.K.N. Rao et al. (eds.), COMADEM 89 International Kogan Page Ltd. 1989.
[6]Mitchell lebold, Katherine McClintic, Robert Campbell, Carl Byington, Kenneth Maynard, Review of Vibration Analysis Methods For Gearbox Diagnostics and Prognostics. Proceedings of the 54th Meeting of the Society for Machinery Failure Prevention Technology, Virginia Beach, VA, May 1-4, p.623-634.
[7] S. Chen, J. Tang, C. Zhou, Z. Hu, Modal Whirling Analysis of Coupled Lateral And Torsional Vibration Of Herringbone Gear. Springer-Verlag Berlin Heidelberg 2013.
[8] I.A. Bednyi, Mathematical Simulation of Epicycle Gear Vibrations in a Planetary Gearbox Using Finite Element Analysis. ISSN 1052-6188, Journal of Machinery Manufacture and Reliability, 2007, Vol. No.36, No.5, pp. 425-429. Allerton Press, Inc., 2007.
[9] Mr. BhavinGajjar, Finite Element Analysis of Gearbox Housing, International Journal for Scientific Research and Development (IJSRD), Vol.02, ISSUE 03,2014, ISSN (online): 2321-0613.
[10] Shrenik M. Patil, Prof. S.M. Pise, Modal and Stress Analysis of differential Gearbox Casing with Optimization, International Journal of Engineering Research and Applications (IJERA), Vol.03, ISSUE 6, ISSN: 2248-9622, Nov-Dec 2013, pp. 188-193.
[11] P.D. Patel, D.S. Shah, Steady State Thermal Stress Analysis of Gearbox Casing by Finite Element Method. International Journal of Mechanical and Industrial Engineering (IJMIE). Vol.-2, Iss-4, 2012, ISSN No.2231-6477.
[12] M.Davis, Y.S. Mohammed, A.A. Elmustafa, P.F. Martin, C. Ritinski, Designing for Static and Dynamic Loading of a Gear Reducer Housing with FEA. ISBN: 978-1-55589-962-2.
[13] Y. Shivraj Narayan, K. Karumanchi, Modeling and Core Cavity Preparation of Side Engine Cover of a Gear box Casing Using PRO/E Software. National Conference on Advances in Mechanical Engineering (NCAME)-2010, 18th December 2010.
[14] Syed R UL Haque, Prof. Dongyan Shi, AzouzRadhia, TauseefAhemad, Static Analysis of Gearbox Casing Using Submodeling Approach in ANSYS.
[15] Fujin Y Yongxiang, Daowen Sn, Wenquan Shen, Weiqiang Xia, Analysis for the Dynamic Characteristic of the Automobile Transmission Gearbox. Research Journal of Applied Sciences, Engineering and Technology (RJASET). 5(4): 1449-1453, 2013 ISSN:2040-7459, e-ISSN:2040-7467, Maxwell Scientific Organization, 2013.

[16] Handbook Of Gear Design By Gitin M Maitra.

BIOGRAPHIES:

Parag V. ButeB.E.in Production Engineering from College of Engineering & Technology, Akola in the year 2007. Currently pursuing M.E (Mechanical Design Engineering) at Dr. D. Y. Patil Institute of Engineering And Technology Ambi, Pune.

R. J. Patil, Principal, Dr.D.Y.Patil Instituteof Engineering and Technology, Ambi-Pune Maharashtra, India

Swapnil S. Kulkarni, Director, Able Technologies India Pvt. Ltd., Pune. The Company offers Engineering Services and Manufacturing Solutions to Automotive OEM's and Tier I and Tier II Companies. He is a Graduate in Industrial Engineering with PG in Operations Management. With around 20 years of working experience in the domain of R&D, Product Design and Tool Engineering, he has executed projects in the Automotive, Medical and Lighting Industry. His area of interest is Research and Development in the Engineering Industry as well as the emerging sector of Renewable Energy.