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ASSESSING VIBRATION FOR GEAR USED IN A MACHINE TOOL APPLICATION THROUGH FINITE ELEMENT METHODOLOGY

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ABSTRACT

The phenomenon of resonance is prominent upon concurrence of the excitation frequency with the natural frequency of the part or the sub-assembly. The gear train and the housing is susceptible to the detrimental effects of this phenomenon by virtue of its nature of construction. Typically, the housing of the gear train contains gears with points at high speed of operation. For research, the vibration for such a Gear is being considered for this work. Popular machine tool like a lathe is being identified for expanding the application of this work. F.E. Modeling shall be pursued for deriving analytical solution to the problem while physical experimentation would be done to offer inputs to the work and validate the model at the initial phase of work. Hyper Works is being considered as a CAE tool for Pre-processing, Solving and Post processing. The experiment would be performed on the physical setup for the existing/ benchmark case.

KEYWORDS— *Mass, Stiffness, Damping, Vibration Control, Gears.*

I. INTRODUCTION

All machines with moving parts give rise to sound and vibration. Each machine has a specific vibration signature related to the construction and the state of the machine. If the state of the machine changes the vibration signature will also change. A change in the vibration signature can be used to detect incipient defects before they become critical. This is the basics of many condition monitoring methods. Condition monitoring can save money through increased maintenance efficiency and by reducing the risk of serious accidents by preventing breakdowns. The use of vibration analysis as one of the fundamental tools for condition monitoring has been developed extensively over a period of approximately 35 years. With the parallel developments in electronic equipment, transducers, computers and software nowadays machine supervision is almost completely automated. In the present work the authors present a review of a variety of diagnosis techniques for gearbox fault identification with particular regard to vibration analysis. The vibration techniques were developed with two main purposes. The first purpose is to separate the gearbox related signal from other components and to minimize the noise that may mask the gearbox signal, especially in the early stages of the fault. Vibration analysis was used former mainly to determine faults and critical operation conditions. Nowadays the demands for condition monitoring and vibration analysis are no more limited trying to minimize the consequences of machine failures, but to utilize existing resources more effectively

II. LITERATURE REVIEW

1**.** *Amit Aherwar, Md. Saifullah Khalid,* Gears are important element in a variety of industrial applications such as machine tool and gearboxes. An unexpected failure of the gear may cause significant economic losses. For that reason, fault diagnosis in gears has been the subject of intensive research. Vibration signal analysis has been widely used in the fault detection of rotation machinery. The vibration signal of a gearbox carries the signature of the fault in the gears, and early fault detection of the gearbox is possible by analyzing the vibration signal using different signal processing techniques.

2**.** *Jianming Yang,* In this paper, the vibration of a gear train with multi-meshes under both deterministic and random loads is investigated. The equation of motion is solved with stochastic Newmark algorithm and the responses of the displacements, including means and standard deviations, are obtained through numerical integration. The nonlinearity caused by the clearance between meshing teeth is treated with statistic linearization techniques. Examples of gear trains working under heavy load and light load are simulated and the result shows that the system behaves linearly under heavy load and nonlinearly with softening spring character under light load.

3. *Zhonghong Bu, Geng Liu , Liyan Wu,* A generalized dynamic model for herringbone planetary gear train (HPGT) is developed to investigate its modal properties. The model includes the axial vibration of two helical ring gears in addition to three planar degrees of freedom for the carrier and all gears. Four stiffness coefficients are applied to describe the asymmetry and the interaction of the oil film stiffness of journal bearings for supporting the planets. Vibration modes are classified into rotational and axial mode, translational mode, planet mode, rotational and axial ring mode and translational ring mode. For each type of mode, the reduced-order eigenvalue problems are derived according to the modal properties. The formulas for calculating themodal strain and kinetic energy distributions are also given for each mode. The proposed dynamic model and analysis methods can be applied to HPGT with any number of planets. Only when the asymmetric interaction exists in journal bearings, will the dramatic change of mode shape for translational mode occur. The new relations between deflections of planets in translational mode are also derived in this research.

4**.** *Marianne Mosher, Anna H. Pryor, and David G. Lewicki,* In this paper, the authors show a detailed analysis of the vibration signal from the destructive testing of a spiral bevel gear and pinion pair containing seeded faults. The vibration signal is analyzed in the time domain, frequency domain and with four time-frequency transforms.

5. *Alexander Kapelevich Graco,* Conventional involute spur gears are designed with symmetric tooth side surfaces. It is well known that the conditions of load and meshing are deferent for drive and coast tooth's side. Application of asymmetric tooth side surfaces enables to increase the load capacity and durability for the drive tooth side. Therefore, the geometry and design of asymmetric spur gears represents an important problem. There are several articles about involute gears with asymmetric, or so-called, buttress teeth. They consider the low pressure angle profile for the drive side and high pressure angle profile for the coast side teeth. Such an approach enables to decrease the bending stresses and keeps contact stresses on the same level as for symmetric teeth with equal pressure angle. However, this design is accompanied by raising mesh stiffness, increasing noise and vibration with frequency of the cycle of meshing. It does not affect the load capacity limited by contact stresses.

6**.***Mitchell Lebold, Katherine McClintic, Robert Campbell,Carl Byington, and Kenneth Maynard,* Vibration analysis for condition assessment and fault diagnostics has a long history of application to power and mechanical equipment. The interpretation and correlation of this data is often cumbersome, even for the most experienced personnel, and thus automated processing and analysis methods are sometimes sought. As such, statistical features are commonly used to provide a measure of the vibration level that can be compared to a threshold value indicative of a failed condition. Many feature vectors have been developed over the years and are well documented in the literature. What is not clear from the literature is the details associated with each feature so that the results are consistent among users. Preprocessing is vaguely stated and terms, such as “residual signal”, are commonly used yet can mean different techniques. An attempt has been made to define the terms, establish the preprocessing needed for each feature, and provide the details needed to produce consistent results.

7**.** *G.Dalipaz, A.Rivola and R.Rubini,* This paper deals with gear condition monitoring based on vibration analysis techniques. The detection and diagnostic capability of some of the most effective techniques are discussed and compared on the basis of experimental results, concerning a gear pair affected by a fatigue crack. In particular, the results of new approaches based on time-frequency and cyclostationarity analysis are compared against those obtained by means of the well accepted

cepstrum analysis and amplitude and phase demodulation of meshing harmonics. Moreover, the sensitivity to fault severity is assessed by considering two different depths of the crack. The effect of choosing different transducer locations and different processing options are also shown.
8. *Jiri Tuma,* This paper will review practical techniques and procedures employed to quiet gearboxes and transmission units. The author prefers solving the gear noise problem at the very source to introduce an enclosure as a means to reduce radiated noise, which seems to be easy but its effect on the sound pressure level is small. The gearbox noise problem solution is focused on the improvement of gear design; on the verification of its effect on the radiated noise and the determination of the gears' contribution to the truck's or car's overall noise levels and on the analytical and/or numerical computer-based tools needed to perform the signal processing and diagnostics of geared axis systems. All of the analytical methods are based on the time and frequency domain approach. Special care is addressed to the smoothness of the drive resulting from the transmission error variation during a mesh cycle. This Paper will review the progress in technique of the gear angular vibration analysis and its effect on gear noise due to the self-excited vibration. This presentation will include some examples of the use of such approaches in practical engineering problems.
9. *Abhilesh Warade,* Disks are important structural elements in engineering application as well as in everyday life, such as pressure vessel, missiles, liquid containers, and ship structures. The turbine, brake disc and diaphragm clutch spring are the well-known examples for the industrial application of the annular plate with radial cracks. Circular plates are fundamental structural elements in ocean engineering applications from offshore platforms to under water acoustic transducers.5 Circular annular plates with radial cracks are extensively used in the construction of aircraft, ships, automobiles and other vehicles. As disks are often subjected to transverse vibrations and these vibrations decrease the mechanism's capabilities. Since the dynamic performance is always of interest, hence a circular annular plate with radial cracks, fixed at inner edge and free at outer edge is chosen and its dynamic response is investigated in this dissertation work as mentioned below. Firstly, using FFT analyzer, natural frequencies are detected by hitting the plate with impact hammer; the response at a point of a plate is measured by using an accelerometer. FFT analyzer analyzed the output of accelerometer. In the second method, the clamped disk was mounted on exciter and different mode shapes were detected by varying the exciting frequency. Mode shapes are snapped in photo camera to compare with FEM (ANSYS) mode shapes of same test specimens. i.e. Modal analysis is performed on the structure to analyze and measure the system's response to find natural frequency of the annular disc with radial cracks. In the third method, FEM software package (ANSYS) is used for vibration analysis of annular plates of same ratio of inner to outer radius but variable numbers and variable lengths of radial cracks with same boundary condition for determining different parameters like natural frequency, mode shapes. Theoretical and experimental results obtained are compared at the end and found similar results.
[10] This paper postulates the initial primitive stage in the design analysis of a Genset silencer. The geometry of the exhaust system is modeled by using a conventional FEM package after considering specified properties of material, dimensions of silencer. Modal Analysis of the muffler is carried out and the results are compared with the reading taken on FFT analyzer, so as to distinguish working frequency from natural frequency, avoid resonating condition and to find the stress concentration at various regions of silencer

III. PROBLEM DEFINITION

The Sponsoring Company has received an assignment from its Client for determining the best configuration of the Gear Box and its housing for a reliable and safe operation while minimizing the adverse effects of vibrations during power transmission. While accomplishing the objective, a suitable methodology to be introduced as an alternative to the conventional method of experimentation for each iteration or change. At the moment, the Client using its historical data over the vibrations induced or the performance of the gearbox. Any variation in the levels for the design parameters affects the performance. There is no means of predicting the response parameter with the available data. A convenient and reliable methodology for addressing the problem is sought through this dissertation work.

Fig1: Typical Gear used for Power transmission

IV. OBJECTIVES FOR THIS WORK

For this work, the scope would be limited to the following:
1) Identifying the natural frequency for the subject gear (singular gear) assigned for the task
2) Using Finite Element Methodology for arriving at suitable levels for the parameters while evaluating performance for each variation introduced
3) Conducting Frequency Response Function (FRF) analysis for determining stresses induced due to vibrations
4) Benchmarking the existing configuration for physical experimentation to validate the model. Conducting experiment for the benchmarked (existing) gear using FFT analyzer or suitable technique.
5) Recommending suitable configuration of the gear (material or geometry or mating conditions) through analogy for the validated model for Benchmark.

V. EXPERIMENTATION

Physical experimentation to be performed over the gear designed for addressing the current function. Suitable apparatus with FFT analyzer to be used for identifying the natural frequencies of the gear. The subject range of `frequencies of concern' to be identified and marked for deliberation further. Readings are normally recorded after the component is subjected to an excitation (using a mallet/ soft hammer).

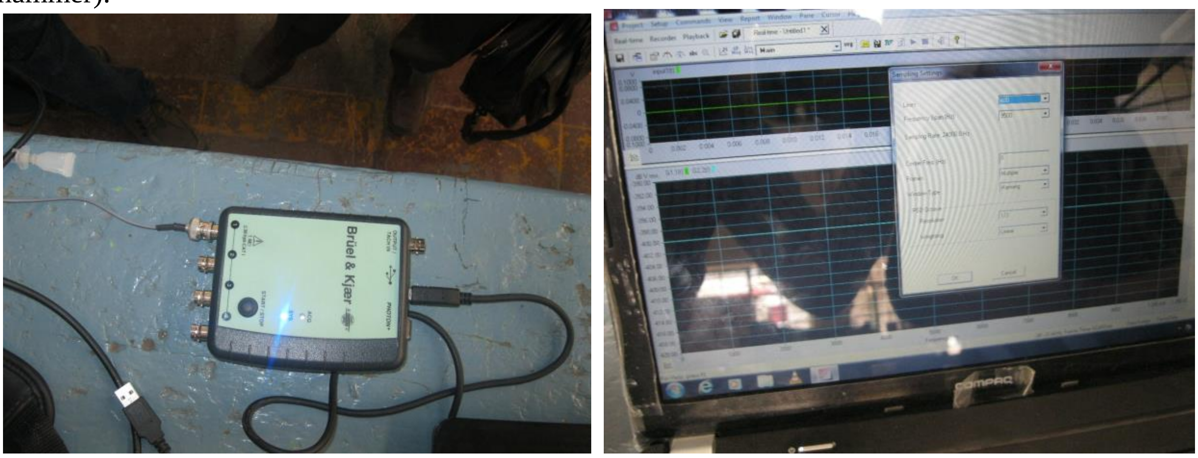

Fig2: Experimental setup for Gears

VI. VALIDATION

The concurrence of the values for the experiment with respect to the ones derived by Finite Element Modeling is compared. A good match indicates that the thesis could be valid as two differing methodologies (FEA and Physical Experimentation) tend to have a similar result. Normally a variation ranging from 5% to 20% could be observed in the reading recorded by the individual methodologies.

VII. CONCLUSION

Most authors seem to agree that transmission error is an important excitation mechanism for gear noise and vibration.
The finite element method is most widely or find a real model of the geared set using the stress analysis in the pair of gears. The development off finite element analysis model of the spur gear assembly to simulate the contact stress calculation and bending stress calculation is play more significant role in the design of gears. The study is show that Hertz theory is the basis of contact stress calculation and Lewis formula is use for calculating bending stress is a pair of gear. Theoretically result obtained by Lewis formula and hertz equation and result found by comparable with finite element analysis of spur gear.

VIII. FUTURE SCOPE

The scope can be further extended by:

1. Experimental Model analysis for prototype model.
2. Effect of thickness and mass optimization of gear on natural frequency and its mode shape.
3. Optimized gear model by changing different material.

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REFERENCES

[1] Amit Aherwar, Md. Saifullah Khalid. “Vibration Analysis Techniques For Gearbox Diagnostic: An International Journal of Advanced Engineering Technology” E-ISSN 0976-3945.
[2] Jianming Yang, “Vibration analysis on multi-mesh gear-trains under combined deterministic and random excitations”, Mechanism and Machine Theory 59 (2013) 20–33
[3] Zhonghong Bu, Geng Liu , Liyan Wu , “Modal analyses of herringbone planetary gear train with journal bearings” Mechanism and Machine Theory 54 (2012) 99–115.
[4] Marianne Mosher, Anna H. Pryor, and David G. Lewicki, “Detailed Vibration Analysis of Pinion Gear with Time-Frequency Methods” NASA/TM–2003-212269.
[5] Alexander Kapelevich Graco, “Geometry and design of involute spur gears with asymmetric teeth”, Mechanism and Machine Theory 35 (2000) 117-130.
[6] Mitchell Lebold, Katherine McClintic, Robert Campbell,Carl Byington, and 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, 2000, p. 623-634.
[7] G.Dalipaz, A.Rivola and R.Rubini, “Gear fault monitoring: comparison of vibration analysis techniques”, 2-I-40136 Bologna, Italy.
[8] Jiri Tuma, “Gearbox Noise and Vibration Prediction and Control”, International Journal of Acoustic and Vibration, Vol.14, No.2, 2009.
[9] Abhilesh Warade, “Vibration Analysis Of Annular Disc With Periodic Uniform Radial Slots While Disc Is Clamped At Inner Edge And Free At Outer Edge”, E-ISSN 0976-3945.
[10] Mr. K.S. Tanpure, “Vibrational Analysis Of Genset Silencer Using FEA & FFT Analyzer”, ISSN: 2349-6193.

BIOGRAPHY

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