Detection of Gear Tooth Defects by using MATLAB & FEA Technique - Review

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Abstract— In gearboxes, load fluctuations on the gearbox and gear defects are two major sources of vibration. Further, at times, measurement of vibration in the gearbox is not easy because of the inaccessibility in mounting the vibration transducers. Vibration analysis techniques are used for detection of fault in gear system, fluctuation in gear load such as a method for monitoring the evolution of gear faults based on the newly developed time- frequency analysis through FEA, in which analysis is carried out with the decomposed current signal to trace the sidebands of the high frequencies of vibration,. It is also helpful tool for health monitoring of gears. Acoustic signal can be used effectively along vibration signal to detect the various local faults in gearboxes using the wavelet transform technique. Two commonly encountered local faults, tooth breakage and tooth crack were simulated. In fault simulating, two very similar models of worn gear have been considered with partial difference for evaluating the preciseness of the proposed algorithm. Moreover, the processing of vibration signals has become much more difficult because a full-of-oil complex gearbox system has been considered to record raw vibration signals. Raw vibration signals were segmented into the signals recorded during one complete revolution of the input shaft using tachometer information and then synchronized using piecewise cubic hermit interpolation to construct the sample signals with the same length.

Key words: Gear Defects, Vibration Analysis, Finite Element Analysis, Acoustic Signal, Tooth Breakage, Raw Vibration Signals Keywords—component; formatting; style; styling; insert (key words)

I. Introduction

Gear Boxes constitute a very vital link in the transmission chain of a variety of equipment and machinery. The earliest drives used cylindrical rods inserted radically in one wheel meshing with similar rods mounted axially in another wheel. This type of drive performed satisfactory, though inefficiently, at low speeds and low loads but trouble was encountered as soon as load or speed was raised [1].

The increasing trend towards predictive maintenance has led to the development of a vast number of machine condition monitoring techniques. Of these techniques, vibration analysis and oil analysis are the two distinct and most readily used methods in determining mechanical failures in common components of industrial machinery such as gears and bearings. [2]

Gear mechanisms are an important element in a variety of mechanical systems. For that reason, early fault detection in gears has been the subject of intensive investigation and many methods based on vibration signal analysis have been developed. Conventional methods include crest factor, kurtosis, power spectrum and cepstrum estimation, time-domain averaging and demodulation, which have proved to be effective in fault diagnosis and are now well established [3].

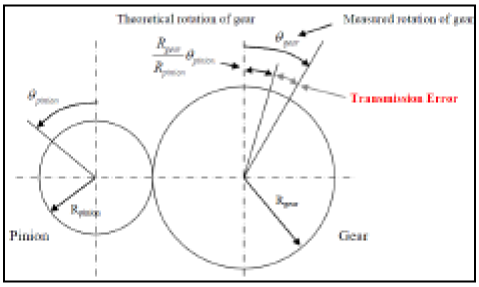
In gearboxes and power drive trains in general, gear damage detection is very critical and its early diagnosis can lead to increased safety in aviation and in various industrial applications. Few research teams have published experimental data coming from long-term testing to study the effect of natural gear pitting mostly upon vibration recordings. The interest for applications of acoustic emission (AE) for condition monitoring in rotating machinery is relatively new and has grown significantly over the last decade. As AE mainly detects high-frequency elastic waves, it is not affected by structural resonances and typical mechanical background noise (under 20 kHz). The AE from helical gears based mainly in the root-mean-square of the recorded signals.AE to spur gears in a gearbox test-rig. They simulated pits of constant depth but variable size and AE parameters such as energy, amplitude and counts were monitored during the test. AE was proved superior over vibration data on early detection of small defects in gears. [1]

A. Problem Description

If the gears were perfectly rigid and no geometrical errors or modifications were present, the gears would transmit the rotational motion perfectly, which means that a constant speed at the input shaft would result in a constant speed at the output shaft. The assumption of no friction leads to that the gears would transmit the torque perfectly which means that a constant torque at the input shaft would result in a constant torque at the output shaft. No force variations would exist and hence no vibrations and no sound (noise) could be created. However, in reality, there are geometrical errors, deflections and friction present, and accordingly, gears, by their inherent nature, cause vibrations due to the large pressure which occurs between the meshing teeth when gears transmit power. Meshing of gears involves changes in the magnitude, the position and the direction of large concentrated loads acting on the contacting gear teeth, which as a result causes vibrations. Extended period of exposure to noise and vibration are the common causes of operational fatigue, communication difficulties and health hazards. Reduction in noise and vibration of operating machines has been an important concern for safer and more efficient machine operations [2].

B. Transmission Errors in Gears

Transmission Error (TE) is one of the most important and fundamental concepts that forms the basis of understanding vibrations in gears. The name 'Transmission Error' was originally coined by Professor S. L. Harris from Lancaster University, UK and R.G. Munro, his PhD student at the time. They came to the realization that the excitation forces causing the gears to vibrate were dependent on the tooth meshing errors caused by manufacturing and the bending of the teeth under load. TE is defined as the deviation of the angular position of the driven gear from its theoretical position calculated from the gearing ratio and the angular position of the pinion [3]. The concept of TE is illustrated in Figure below:-



$$TE = \left(\theta_{gear} - \frac{R_{pinion}}{R_{gear}} \theta_{pinion} \right)$$

Fig 1.2 Concept of Transmission Error (TE)

C. Factors Affecting Transmission Errors

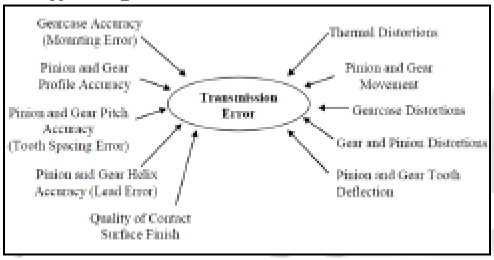


Fig. 1.3: Factors Affecting TE

D. Project Inception

All Naval Warships are fitted with latest state of art transmission systems. The existing defect analysis method using vib-10, SPM and frequency spectrum analysis do not help in identifying defects at embryonic stage. This dissertation attempts to bring a practical solution to identify the gearbox faults at the initial stage.

E. Project Methodology

- To collect vibration signature of good gears and defective gear (missing tooth) from Gearbox Dynamics Simulator (GDS).
- Real time vibration signatures of good and defective gears are to be acquired with the help of accelerometers using Data Acquisition System (DAS).
- Modelling of gear box containing good and defective gears would be carried out using Solid Works.
- The same model will then exported to ANSYS 14 for simulation and further analysis.
- Transient analysis would be carried out initially with only two spur gears, gearbox housing and the two shafts to get feel of simulation and analysis in FEM environment.

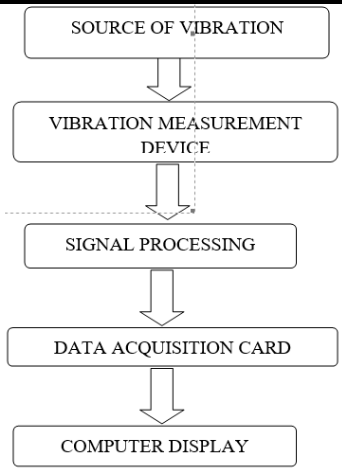


Fig. 1.5: Steps for Detecting the Fault in System

II. LITERATURE REVIEW

A. History

There has been a great deal of research on gear analysis, and a large body of literature on gear modeling has been published. The gear stress analysis, the transmission errors, and the prediction of gear dynamic loads, gear noise, and the optimal design for gear sets are always major concerns in gear design. The first study of transmission error was done by Harris [3]. He showed that the behaviour of spur gears at low speeds can be summarized in a set of static transmission error curves. In later years, Mark et al [3] analyzed the vibratory excitation of gear systems theoretically. He derived an expression for static transmission error and used it to predict the various components of the static transmission error spectrum from a set of measurements made on mating pair of spur gears. Kohler and Regan [6] discussed the derivation of gear transmission error from pitch error transformed to the frequency domain. Kubo et al estimated the transmission error of cylindrical gears using a tooth contact pattern. The current literature reviews also attempt to classify gear model into groupings with particular relevance to the research. The following classification seems appropriate [6].

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. This paper describes the practical aspect of vibration phenomena and the measurement requirements of a general monitoring system consisting of data collection with data reports in digital manner, followed by the acquisition of the vibration values for faulty and good Gears. [6]

B. Review of Papers

1) As per T. H. Loutas, D. Roulias view in there paper, The monitoring of progressive wear in gears using various non-destructive technologies as well as the use of advanced signal processing techniques upon the acquired recordings to the direction of more effective diagnostic schemes, is the scope of the present work. For this reason multi-hour tests were performed in healthy gears in a single-stage lab scale gearbox until they were seriously damaged. Three on-line monitoring techniques are implemented in the tests. Vibration and acoustic emission recordings in combination with data coming from oil debris monitoring (ODM) of the lubricating oil are utilized in order to assess the condition of the gears.

The fault diagnosis of machines is the most important thing in the manufacturing process. The early identification of possible faults affecting a machine and the evaluation of their severity can reduce off-line time, maintenance periods, forecast residual life, and avoid accidents and dangerous breakdown. The vibration signal of machine covers all the information of the running machine. Mathematical models make it possible to simulate machining vibration quite accurately, but in practice it is always difficult to avoid vibration. As the faults often appear when the machine is vibrating, it is an important measure of fault diagnosis to analyze the signals of vibration. Modal analysis is useful method to analyze mechanical vibration signal. And the path of modal analysis is paralleled with that taken by finite element analysis. A modal analysis calculates the natural modes and natural frequencies of a given system, but not necessarily its full time history response to a given input [2]. The natural frequency and natural modes of a system is dependent only on the stiffness of the structure and the mass that participates with the structure. If mechanical structure had some defects and faults, the natural frequencies and natural modes are necessarily different from that of the normal state.

A gearbox has found wide application in agricultural, industrial, construction, mining and automotive equipment. An unexpected failure of the gearbox may cause significant economic losses. It is, therefore, very important to find early fault symptoms from gearboxes. The gearbox is analyzed by modal analysis method. The results are presented in detail. The natural frequency and natural modes of the gearbox are shown in the result. It is helpful to find the defects or faults of the gearbox.

2) As per S. Ebersbach, Z. Peng view in there paper. The aim of this work is to investigate the effectiveness of combining both vibration analysis and wear debris analysis in an integrated machine condition monitoring maintenance program. To this end, a series of studies was conducted on a spur gearbox test rig. After a test under normal condition was conducted to obtain the baseline information of the test rig, a number of different machine defect conditions were introduced under controlled operating conditions, corresponding to :-

(i) Constant overloads conditions and (ii) cyclic load conditions. The data provided by wear debris analysis was compared with vibration analysis spectra in order to quantify the effectiveness of both vibration analysis and wear debris analysis in predicting and diagnosing machine failures.

This paper presents an optimized gear fault identification system using genetic algorithm (GA) to investigate the type of gear failures of a complex gearbox system using artificial neural networks (ANNs) with a well-designed structure suited for practical implementations due to its short training duration and high accuracy. For this purpose, slight-worn, medium-worn, and broken-tooth of a spur gear of the gearbox system were selected as the faults. In fault simulating, two very similar models of worn gear have been considered with partial difference for evaluating the preciseness of the proposed algorithm. Moreover, the processing of vibration signals has become much more difficult because a full-of-oil complex gearbox system has been considered to record raw vibration signals. Raw vibration signals were segmented into the signals recorded during one complete revolution of the input shaft using tachometer information and then synchronized using piecewise cubic hermite interpolation to construct the sample signals with the same length. Next, standard deviation of wavelet packet coefficients of the vibration signals considered as the feature vector for training purposes of the ANN. To ameliorate the algorithm, GA was exploited to optimize the algorithm so as to determine the best values for ‘‘mother wavelet function”, ‘‘decomposition level of the signals by means of wavelet analysis”, and ‘‘number of neurons in hidden layer” resulted in a high-speed, meticulous two-layer ANN with a small-sized structure. This technique has been eliminated the drawbacks of the type of mother function for fault classification purpose not only in machine condition monitoring, but also in other related areas. The small-sized proposed network has improved the stability and reliability of the system for practical purposes.

The application of a condition-based maintenance strategy used for detection and diagnosis of incipient faults can help us to minimize avoidable costs and impediments caused by the need to perform ad hoc repairs. Gearboxes consisting of three major components (gears, bearings, and shafts) are considered to be one of the essential systems on account of its influential applications in a wide domain of industries (e.g. machine tools and vehicles). As more than half of the failures in gearboxes are due to gear defects, the gear faults have been considered as a case study for the proposed technique.

In general, acoustic emission and vibration analysis are two main centers of fault detection and diagnosis systems in machine condition monitoring. In this paper, vibration signals established as the way of recording required dataset because of the ease of measurement and the rich contents of information. To analyze raw vibration signals, a simultaneous time–frequency analysis method which maps one-dimensional signals into two dimensional spaces of time and frequency was applied because of non-stationarity of vibration signals. Wavelet analysis, the most popular one for analyzing the non-stationary signals, overcomes the drawbacks of other techniques by means of analytical functions that are local in both time and frequency). Therefore, in pre-processing and feature extraction phase of the research, wavelet transform (WT) has been used to take out proper features. To bolster this recommendation, Leducq applied wavelet transform to analyze the hydraulic noise of the centrifugal pump which is probably the first paper in application of wavelet transform in machine diagnostics. Momoh and, moreover, used both fast Fourier transform (FFT) and wavelet transform (WT) to obtain processed vibration signals to identify and pinpoint the location of the faults in power distribution systems. The prior research demonstrates the wavelet transform as the most reliable technique for gear condition monitoring and a capable technique to recognize the incipient failures and to identify different types of faults simultaneously. The most indispensable challenge in wavelet analysis is the selection of the mother wavelet function as well as the decomposition level of signal. As a result of the use of dyadic discrete wavelet transform (DWT), orthogonal wavelets have been applied in this research; among them Daubechies (DB) wavelets have been widely implemented as it matches the transient components in vibration signals.

3) As per S.J. Loutridis view in there paper, A method for monitoring the evolution of gear faults based on the newly developed empirical mode decomposition scheme is presented. A theoretical model for a gear pair with a tooth root crack was developed. Experimental vibration signals from a test rig were

decomposed into oscillatory functions called intrinsic mode functions. An empirical law, which relates the energy content of the intrinsic modes to the crack magnitude, was established. The modal energy is thus associated with the deterioration in gear condition and can be utilized for system failure prediction. In addition, it is shown that the instantaneous frequency of the vibration signal is a sensitive indicator of the existence of damage in the gear pair.

In the case of continuous systems, where masses are distributed over the structure (gearbox casing), other methods, such as finite element analysis (FEA), are often used to study the behaviour of the structure. The use of FEA results in a large number of DOF, which in turn complicates simulating the whole system's response to the presence of nonlinearities and to gear and bearing faults. This in turn limits the validity of the simulated results and restricts their later usage in the diagnostics and prognostics of the gears and bearings. Hence there is a growing trend to use FE model reduction methods to create accurate low order dynamic models before calculating Eigen frequencies and eigen modes. In this paper, a dynamic reduction technique, the so-called, Craig–Bampton reduction technique, is utilized to reduce the finite element model of the UNSW gearbox casing. The reduced model is then connected to a lumped parameter model of the internals (shafts, gears and bearings) which has the capacity to simulate faults [3]. The combined model is run in Simulink environment with localized and extended inner and outer race faults. The response from the combined model at the connecting nodes (bearing centres) and from the modal coordinates is transformed and combined to give the total response at a virtual sensor location, which has been selected to agree with the actual accelerometer position, to compare the results. Thus the total response will not only include the contributions of the dynamics of the internals but also the flexibility and the dynamics of the casing. This makes this approach very attractive as the finite element model has been dramatically reduced from over a hundred thousand degrees of freedom to only 124 DOF.

4) As per Babak Eftekharnejad view in there paper, An Acoustic emission (AE) is one of many technologies for health monitoring and diagnosis of rotating machines such as gearboxes. Although significant research has been undertaken in understanding the potential of AE in monitoring gearboxes this has been solely applied to spur gears. This report presents an experimental investigation that assesses the effectiveness of AE in identifying seeded defects on helical gears; the first known attempt. Additionally vibration analysis has performed to study
the effect of seeded defect on the vibration signature of the meshing gears.

Vibration monitoring is the most investigated and widely used approach of helicopter gearbox fault diagnosis. In this approach, the vibration signals are measured by accelerometers mounted on the housing and analyzed online for fault detection and isolation. There are two basic issues that need to be handled: how many accelerometers needed and where to located them for a best performance of the fault diagnosis. For the problems of sensor location and fault diagnosis, the propagation of vibrations due to the component faults needs to be studied. This project is intended to study the vibrations due impulse force with finite element of gearbox. A finite element model of the whole gearbox was built in ANSYS. Modal analysis and transient analysis were also made. The results of the model were compared with the experimental data and some simple calibrations and validations were also implemented. Vibration monitoring is the most investigated and widely used approach of helicopter gearbox fault diagnosis. In this approach, the vibration signals are measured by accelerometers mounted on the housing and analyzed online for fault detection and isolation. There are two basic issues that need to be handled: how many accelerometers needed and where to locate them for a best performance of the fault diagnosis. Both of these two problems together with fault diagnosis issue make it important to study the propagation of vibrations due to the component faults. Such vibrations can be simulated as the vibrations caused by an impulse on the fault location (usually by hammering the location) and can be measured by accelerometers located in different places on the gearbox. Usually a Mass-lumped model is used to study the vibration propagation. The disadvantage of this method is that it cannot deal with the distributed property of the transmission path of vibration. This project is intended to study the vibration propagation and to simulate the relationship between the vibrations and the impulse input with a finite element model.

First, a finite element model of the gearbox was built with ANSYS. Second, modal analysis of the model was done to study the natural frequencies and mode shapes. Then transient analysis was made for an impulse input on the gearbox. Such impulse input simulates the component fault. The resulted vibrations on several locations (nodes in the finite element model) due to this impulse input were studied. The results of the model with different damping values were also studied and compared with the experimental data. Some methods were employed to calibrate the damping ratio and elasticity moduli by the experimental data to improve the simulation results.

5) As per David Mba view in there paper, acoustic emission (AE) is gaining ground as a non-destructive technique (NDT) for health diagnosis on rotating machinery. The source of AE is attributed to the release of stored elastic energy that manifests itself in the form of elastic waves that propagate in all directions on the surface of a material. These detectable AE waves can provide useful information about the health condition of a machine. This paper reports on part of an ongoing experimental investigation on the application of AE for gear defect diagnosis. Furthermore, the possibility of monitoring gear defects from the bearing casing is examined. It is concluded that AE offers a complimentary tool for health monitoring of gears.

Order tacking has been applied to rotating machinery vibration signal processing extensively. It removes the interference of rotating speed and additive random noise so that it can obtain reliable order spectrum. However, it is difficult to eliminate the noise mixed with original signal, especially multiplicative noise. Fig. 1 shows the order spectrum of the vibration signals from healthy and faulty gearboxes under two different loads. Fault 1 has 50% damage in one tooth in tooth width direction whereas Fault 2 has 50% damage in two teeth. So Fault 2 is more serious than Fault 1 due to more damaged teeth. However, from these figures, the amplitudes of the tooth meshing frequency (order 34 which is the tooth number of the pinion of the 1st gear pair) and its sidebands cannot provide a trend consistent with the severity of the damage. Although the figure shows some increase feature by amplitudes, it is hard to decide the severity of the faults based on it. To extract a reliable feature from gearbox vibration signal, time synchronous average for order tracking technique is used to process the raw signal firstly. It is not only to remove random noise including short time transient interference, but also generate the definite periodical signal to release over-decomposition or mode mixing in EEMD and select special IMFs for the following analysis. Secondly, The TSA signal is decomposed into IMFs by EEMD method. Since TSA signal retains the periodic feature of gear vibration to maximum. According to IMF's periodicity feature, only several IMFs are be identified and selected for fault diagnosis. Additionally, to avoid the problem with mode mixing more, three improvements are also applied to the analysis process:

- Terminate EEMD when the frequency range of IMF is lower than shaft frequency. Because characteristic frequencies are usually higher than shaft frequency in gearbox vibration signal processing.
- Select the IMFs which exhibit more periodic characteristics. In theory, the vibration signal of gearbox should be periodic. IMFs obtained from TSA signal thus should be periodic. In contrast, the non-periodic IMFs may result from the noise or the other origins in the EMD process and could be ignored.
- Combine the selected IMFs into one IMF as gearbox feature signal for subsequent processing if more than one IMF is selected. This avoids the over-decomposition problem. Then the order spectrum of the combined IMF is calculated. Finally, based on the order spectrum of IMF, feature for gearbox fault diagnosis is extracted to achieve robust performance under different operating conditions from remote locations.

6) As per G Diwakar, Dr. M R S Satyanarayana views in there paper, The new generation of condition monitoring and diagnostics systems differs by the detailed solution of diagnostic problems that allows making a step from machine vibration state monitoring to the monitoring of the machine technical condition. A real-time system for condition monitoring of Gearbox can reduce expenses of maintenance of it used in industry. It is based on vibration signature analysis concept using the vibration information as acquired from the various bearing locations of a Gearbox. The aim of vibration monitoring is the detection of changes in the vibration condition of the object under investigation during its operation. The cause of such changes is mainly the appearance of a defect. The vibration measurements can be conducted without any change in the operation mode of the object. The objective of this paper is to detect the fault in Gearbox by the interpretation of vibration data and spectrums. The spectrums shows the fault in Gearbox when Gearbox is operated at different Gears on full loads.

Gearbox is used widely as one of critical mechanical components in industry. Its condition monitoring and fault diagnosis are essential for achieving maximum service availability. In recent years, a great deal of amount of work has been carried out to develop accurate diagnosis methods based on vibration measurement. The main direction in this field is to research more effective signal processing techniques including time domain statistical parameters (kurtosis, crest factor etc.), frequency domain analysis methods (Fourier spectrum, cepstrum, wavelet, etc.), joint-time frequency representation and so on [1-3] to obtain reliable and sensitive features for incipient fault diagnosis. The challenge in processing vibration signal from gear box is that the signal to noise ratio is low. Many factors such as operating conditions, background noise and interferences from driving motor or other equipment are all included in the measured signal. In addition, vibration sensors have to be installed remotely in many cases because of access limitation. The signals recorded far away from gear box have is more interferences due to long vibration transmission path. Therefore, more advanced methods are required to process the signals to obtain a feature which is robust to different noise and independent of operating conditions. In this paper, an ensemble empirical model decomposition (EEMD) based method is proposed by combing EEMD with order tracking technique to extract the diagnostic feature from vibration signal adaptively. Time synchronous average (TSA) in order tracking method can help to obtain a definite periodic signal and reduce the influences from noise and the uncertainty during the adaptive process of EEMD. This method is then evaluated using the vibration data of a two stage helical gearbox diagnosis with different severity of gear damages under different operating conditions from different sensor locations.

7) As per N. Baydar and A. Ball views in there paper, Vibration analysis is widely used in machinery diagnostics and the wavelet transform has also been implemented in many applications in the condition monitoring of machinery. In contrast to previous applications, this paper examines whether acoustic signal can be used effectively along vibration signal to detect the various local faults in gearboxes using the wavelet transform. Two commonly encountered local faults, tooth breakage and tooth crack, were simulated. The results from acoustic signals were compared with vibration signals. The results suggest that acoustic signals are very affective for the early detection of faults and may provide a powerful tool to indicate the various types of progressing faults in gearboxes.

Vibration signals measured from a gearbox are complex multi component signals; generated by tooth meshing, gear shaft rotation, gearbox resonance vibration signatures; however, because the measured vibration signals are often disturbed by uncertain impulses and random noises [1], it is essential to employ some signal processing techniques in the fault diagnosis to attenuate the effects of disturbances and ensure that more accurate gear fault features can be extracted. In most of gear fault diagnosis systems, the demodulation technique is often used for the purpose of fault detection and diagnosis. When a gear has a local fault, the vibration signal of the gearbox may contain amplitude and phase modulations that are periodic with the rotation frequency of the gear. This is known as modulation, since modulating frequencies are caused by certain faults of machine components including gear, bearing, and shaft, the detection of the modulating signal is very useful to detect gearbox fault. The modulation of the meshing frequency, as a result of faulty teeth, generates sidebands, which are frequency components equally spaced around a centre frequency. The centre frequency called the carrier frequency is the gear mesh frequency or the resonant frequency of an accelerometer [2]. The process of restoring the modulating signal that is mixed with a carrier signal is called demodulation.

In narrowband (NB) demodulation techniques, as the name implies the idea is to select an interesting frequency band for further analysis instead of analyzing the whole frequency-domain. This is performed by plotting the spectrum and selects the frequency band in frequency-domain. Hence, one is performing filtering of the DFT of the signal instead of filtering the signal in time-domain. The faulty gear generates the impulse with low amplitude level every time in meshing. This low-level impulse has an amplitude-modulating effect on the vibration signal which is visible as high amplitude signal burst in time domain. The modulation effect spreads over a wide frequency range because of the short duration of impulse. Envelope analysis is a practical approach for investigation of such signals, where amplitude modulation presents in characteristic frequencies of the system. The envelope detection technique focuses on a narrow band range in the specified frequency band, which is useful for detecting the low-level impulses that are below the noise level in the [9]. Low pass filtering and FFT based Hilbert transform are the most commonly known methods for envelope detection. However, the normal spectrum FFT based Hilbert transform has advantage for its high speed and so, suitable for real time envelope detection.

8) Amit Aherwar, Md. Saifullah Khalid has been presented a brief review of some current vibration based techniques used for condition monitoring in geared transmission systems. Hongyu Yang, Joseph Mathew and Lin Ma explained various vibration feature extraction techniques for fault diagnosis of rotating machinery in time domain, frequency domain and time-frequency domain. Frequency domain features are generally more consistent in the detection of damage than time domain parameters. Wenyi Wang deduced a very effective method of the resonance demodulation technique for early detection of gear tooth cracks. The proposed scheme focuses on the fact that gear tooth crack will produce vibration impacts that would excite the structural resonances when the cracked tooth is engaged.

Ahmad Ghasemloonia & Siamak Esmaeel Zadeh used two newest fault detection methods, the resonance demodulation technique (R.D), and the instantaneous power spectrum technique (IPS) for gear box fault diagnostic. Fengxing Zhou & Baokang Yan effectively used demodulated resonance technique in fault diagnosis of high speed line rolling mill synchromesh gears.

C. Conclusion for Literature Review

After a brief analysis of some current vibration based techniques used for condition monitoring in geared transmission systems and it is conclude that frequency domain features are generally more consistent in the detection of damage than time domain parameters, so any fault diagnosis method which is based on frequency domain can be selected for project work.

It is also conclude that the envelope analysis and Power Spectrum Density techniques have shown a better representation for fault identification. The Hilbert Transform and PSD techniques are suitable for multiple point defect diagnostics for condition monitoring. It can be conclude for the above literature review that the envelope analysis or demodulation analysis is most suitable and common for diagnosing the bearing faults and can also be used for the detection of gear faults also.

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