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STUDY PROJECT ON VIBRATION ANALYSIS OF SPUR GEAR BOX

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Abstract *:* Gearbox is one of the most widely used transmission systems in the world. However, due to high service load, harsh operating conditions or fatigue, faults may develop in gears. Vibration health monitoring is a non-destructive technique which can be applied to detect faults propagating in gear teeth. The main objective of the work is to detect the Incipient faults in the spur gear. The spur gear is induced with the defects using the Electrical Discharge Machine and damaged gear is installed in the gearbox and signals are collected. The fault symptoms are investigated by comparing the signals from the healthy gearbox with those from the gearbox with a damaged gear. For different defects the vibrations were captured using the Piezo-electric accelerometer and analysed using the MATLAB. The experimental tests have shown that the tooth surface roughness changes and contact length variations will generate impulse vibrations and friction force changes with considerable amplitudes. By the results of this work the problem in the unknown gear can be identified. This method of incipient fault detection is very easy to implement and detect the faults which reduces the time required in disassembly of breakdown machines. The results indicate that the Vibration amplitude intensifies with increase in fault percentage which enables us to identify the damage and replace the gears before breakdown.

***IndexTerms* - Vibration analysis ,Gear box ,Fault diagnosi,Vibration measurement techniques.**

I. INTRODUCTION

Vibration is a mechanical phenomenon whereby oscillations occur about an equilibrium point. The oscillations may be periodic, such as the motion of a pendulum—or random, such as the movement of a tire on a gravel road.

Vibration can be desirable: for example, the motion of a tuning fork, the reed in a woodwind instrument or harmonica, a mobile phone, or the cone of a loudspeaker.

In many cases, however, vibration is undesirable, wasting energy and creating unwanted sound. For example, the vibrational motions of engines, electric motors, or any mechanical device in operation are typically unwanted. Such vibrations could be caused by imbalances in the rotating parts, uneven friction, or the meshing of gear teeth. Careful designs usually minimize unwanted vibrations.

Linear displacement measurements with eddy-current sensors are immune to foreign material in the measurement area. The great advantage of eddy-current non-contact sensors is that they can be used in rather hostile environments. All non-conductive materials are invisible to eddy-current sensors. Even metallic materials like chips from a machining process are too small to interact significantly with the sensors.

Rotary bearings hold rotating components such as shafts or axles within mechanical systems, and transfer axial and radial loads from the source of the load to the structure supporting it. The simplest form of bearing, the plain bearing consists of a shaft rotating in a hole. Lubrication is often used to reduce friction. In the ball bearing and roller bearing, to prevent sliding friction, rolling elements such as rollers or balls with a circular cross-section are located between the races or journals of the bearing assembly. Visual monitoring can sometimes provide a direct indication of the machine’s condition without the need for further analysis. The available techniques can range from using a simple magnifying glass or low-power microscope. Other forms of visual monitoring include the use of dye penetrants to provide a clear definition of any cracks occurring on the machine surface, and the use of heat-sensitive or thermographic paints.

1.2 GEARBOX

INTRODUCTION TO GEARBOX

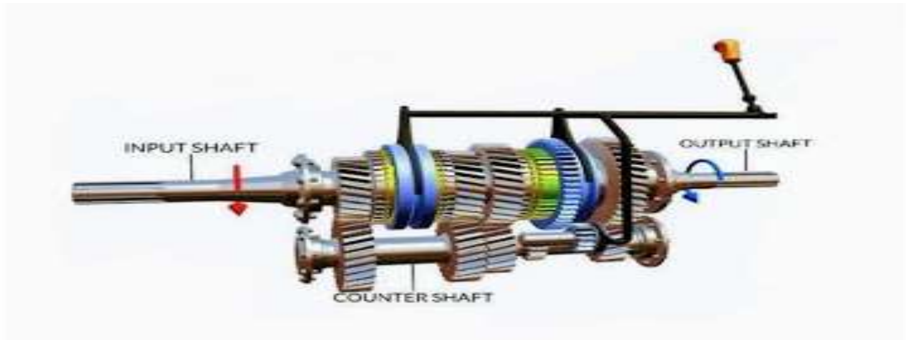


Fig: 1.2 Gear box

High torque is required to start the vehicle from rest, accelerating, hill climbing, pulling a load and facing other resistances. But the IC engine operates over a limited effective speed range which produces a comparatively low torque. In such a situation, the engine is responsible for the stall and the vehicle rests if the speed falls below the limit.

The torque developed by the engine is increasing within limits with the increase of engine speed and reaches a maximum value at some predominant speed. If the engine directly connects to the driving axle, the engine speed may reduce.

Due to the variable nature of the vehicle resistance resulting in load and gradient changes, it requires that the engine power should be available over a wide range of road speeds. Hence, for this reason, the engine speed maintains by using a reduction gear resulting in the road wheels rotating at a proper speed suited to the operating conditions of the vehicle.

Therefore, a single torque multiplication in the rear axle must be interposed and a variable multiplication factor in the gearbox is provided for this purpose.

1.3 BEARING

In today's scenario, maintenance of any machinery is very important in view of downtime of machinery. The bearing sector is one of the examples without which no single rotating machinery works. Products of bearing sector are of high value which leads to the aspects of bearing life & application in more demanding situations.

A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis: or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Most bearings facilitate the desired motion by minimizing friction. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts.

Rotary bearings hold rotating components such as shafts or axles within mechanical systems, and transfer axial and radial loads from the source of the load to the structure supporting it. The simplest form of bearing, the plain bearing consists of a shaft rotating in a hole. Lubrication is often used to reduce friction. In the ball bearing and roller bearing, to prevent sliding friction, rolling elements such as rollers or balls with a circular cross-section are located between the races or journals of the bearing assembly.

Fig 1.10: Roller bearings

2.0 LITERATURE SURVEY

In 1999, N.Tandon, A. Choudhury et.al have presented an article on the vibration and acoustic measurement methods for the detection of defects in rolling element bearing. Detection of both localized and distributed categories of defect has been considered. An explanation for the vibration and noise generation is given. Vibration responses due to localized defects are analyzed using time-domain approach, frequency domain along with signal processing techniques such as the high-frequency resonance technique, REBAM technique and diagnostic system. Other acoustic measurement techniques such as sound pressure, sound intensity and acoustic emission have been reviewed. The vibration response due to distributed defects has been done using acoustic emission.. Recent trends in research on the detection of defects in bearings, such as the wavelet transform method and automated data processing, have also been included. They have concluded that during the vibration measurement the emphasis is on the vibration measuring methods. Vibration in time domain can be measured through parameters such as overall RMS level, crest factor, probability density and Kurtosis. Among these, kurtosis was the most effective. The shock pulse method also gained wide industrial acceptance. Vibration measurement in the frequency domain has the advantage that it can detect the location of the defect. However, the direct vibration spectrum from a defective bearing may not indicate the defect at the initial stage. Some signal processing techniques are, therefore, used. The high-frequency resonance technique is the most popular of these and has been successfully applied by several researchers. Acoustic emission measurements have also been used successfully for detecting defects in rolling element bearings. Demodulation of AE signals for bearing defect detection was also done.The pattern recognition technique and neural networks have b00000000een applied to data obtained from vibration measurements in both time and frequency domains for the detection of defects in rolling element bearings.[1]

2.1 Objectives

The work has been carried out in the following stages:

- To study different methods of fault diagnosis both in gear and bearing.
- To study different faults introduced in gear and bearing and methods to identify the faults.
- To study different lubrication analysis for both gear and bearing.

3.0 METHODOLOGY

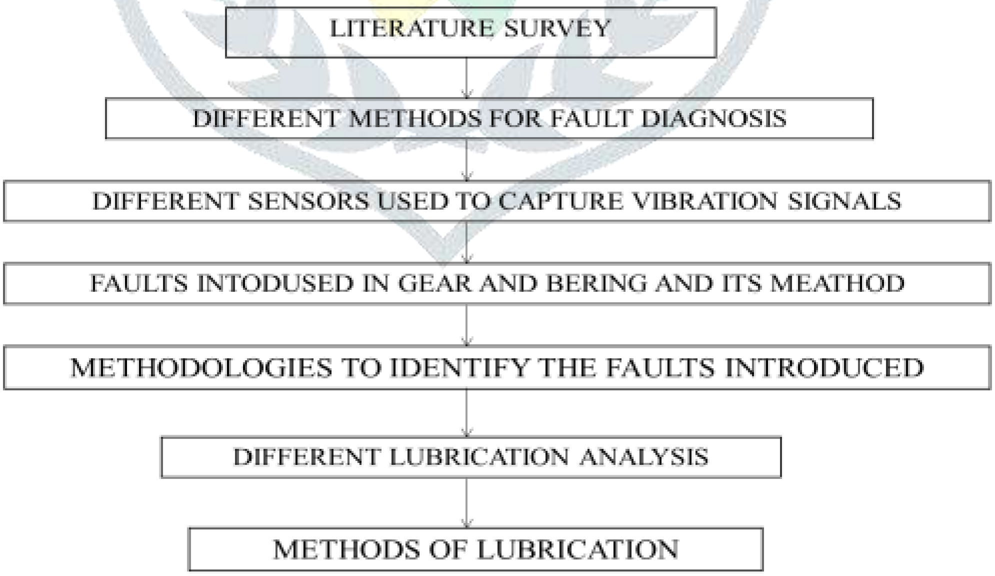


Fig 3.1: Flow chart

4.0 PARAMETERS

4.1 DIFFERENT METHODS FOR FAULT DIAGNOSIS

A gearbox, composed of many elements, usually plays an important part in mechanical transmission. When something goes wrong with a gearbox, vibration data from a gearbox generally display nonlinear and non-stationary properties. Consequently, fault diagnosis of gearboxes is a difficult problem, especially when fault patterns are very similar.

4.1.1 Three methods for data analysis

4.1.1.1 Wavelet transform

Wavelet transform (WT) can be used to process non-stationary data1, 2 . For a signal x(t) , the continuous WT is defined below

$$x(a,b) = \frac{1}{\sqrt{2}}\int_{-\infty}^{+\infty} \varphi\left(\frac{t-b}{a}\right) x(t)\, dt$$

Here, a and b represent the scale and time factors, respectively, the symbol $\Psi(t)$ indicates a wavelet basis function and the symbol $\Psi(t)$ stands for the conjugation of $\Psi(t)$. As a result, there is a distinct lack of adaptability for the analyzed signal in the WT algorithm since a prior knowledge about the basis function is required.

4.1.1.2 Empirical mode decomposition (EMD)

Different from WT, EMD is an adaptive method for processing non-stationary and nonlinear data[3] . By EMD, a signal x(t) can be adaptively decomposed into a group of components falling into different frequency bands and a trend3

$$X(t) = \sum_{i=1}^{k} c_i(t) = r$$

Here, c_i (t) and r denote the ith component and general trend of the signal x(t) , respectively, and k represents the number of the components. In this paper, a k-dimension vector was constructed as characteristic parameters of the signal x(t) , defined as

$$E_j = c^2_j / \sum_{i=1}^{k} c^2_i ,\ j=1,...k$$

EMD (Empirical Mode Decomposition) is an adaptive time-space analysis method suitable for processing series that are non-stationary and non-linear. EMD performs operations that partition a series into 'modes' (IMFs; Intrinsic Mode Functions) without leaving the time domain.

4.1.1.3 Multifractal Detrended fluctuation analysis (MFDFA)

Multifractal Detrended Fluctuation Analysis (MFDFA) is an efficient method to investigate the long-term correlations of the power law of non-stationary time series, in which the elimination of local trends usually depends upon a fixed-constant polynomial order. In this paper, we propose a flexible set of polynomial and trigonometric functions to better detect, and correctly model, hidden local trends in the time series at different scales. We introduce the Multifractal Detrended Fluctuation Analysis with Polynomial and Trigonometric functions (MFDFAPT) method via optimal model selection from an optimization framework.

4.1.2 Three typical classifiers

4.1.2.1 Neural network (NN)

NN is a nonlinear method for machine learning and pattern classification . In theory, a three-layer back-propagation neural network with a large enough number of hidden-layer nodes can serve to mimic dynamical behavior of any nonlinear system . However, it seems to be dealt with only empirically at present how to determine initiative and hidden-layer parameters of a neural network

4.1.2.2 Mahalanobis distance decision rule (MDDR)

The Mahalanobis distance is a measure of similarities of two sets of data8 . Different from the Euclidean distance, the Mahalanobis distance, which is scale-invariant, enables the correlations between data to be examined.

4.1.2.3 Support vector machine (SVM)

A support vector machine (SVM) is machine learning algorithm that analyzes data for classification and regression analysis. SVM is a supervised learning method that looks at data and sorts it into one of two categories. An SVM outputs a map of the sorted data with the margins between the two as far apart as possible. SVMs are used in text categorization, image classification, handwriting recognition and in the sciences.

4.1.3 Comparisons of MFDFA, EMD and WT by NN, MDDR and SVM

4.1.3.1 Fault diagnosis of gearboxes

Table 1. Comparisons of MFDFA, EMD and WT by NN, MDDR and SVM in fault diagnosis of gearboxes for the motor running speed 1200 RPM.

Algorithms	The number of characteristic parameters	Success rates of fault diagnosis (%)		
		NN	MDDR	SVM
MFDFA	5	97.50	97.50	100.00
EMD	11	97.50	93.75	100.00
WT	11	27.50	30.00	35.00

Table 2. Comparisons of MFDFA, EMD and WT by NN, MDDR and SVM in fault diagnosis of gearboxes for the motor running speed 2000 RPM.

Algorithms	The number of characteristic parameters	Success rates of fault diagnosis (%)		
		NN	MDDR	SVM
MFDFA	5	100.00	100.00	100.00
EMD	12	82.50	91.25	95.00
WT	12	36.25	32.50	35.00

a twelve-dimension characteristic vector was constructed for each of EMD and WT. Next, NN, MDDR and SVM were separately used to classify the characteristic parameters extracted by each of MFDFA, EMD and WT and the results are demonstrated in Table 2. As demonstrated in Table 2, although using fewer characteristic parameters for characterizing gearbox conditions, MFDFA delivers a better performance than each of EMD and WT in feature extraction of gearboxes. Furthermore, Table 2 states that SVM performs better than each of NN and MDDR in classification of characteristic parameters. Accordingly, the method associating MFDFA with SVM proves reliable in fault diagnosis of gearboxes .

4.2 DIFFERENT SENSORS USED TO CAPTURE VIBRATION SIGNALS

4.2.2.1 Measuring Vibration with Accelerometers

Accelerometers are small devices that are installed directly on the surface of (or within) the vibrating object. They contain a small mass which is suspended by flexible parts that operate like springs. When the accelerometer is moved, the small mass will deflect proportionally to the rate of acceleration. A variety of sensing techniques can be used to measure the amount of deflection of the mass. Because the mass and spring forces are known, the amount of deflection is readily converted to an acceleration value. Accelerometers can provide acceleration information in one or more axes.

4.2.2.2 Measuring Vibration with Noncontact Displacement Sensors

Fig 4.9: Capacitive non contact displacement sensors

Noncontact displacement sensors mount with a small gap between the sensor (probe) and a surface of the vibrating object. Capacitive and eddy-current displacement sensors are best choices for high-resolution, high-speed measurements. Because their outputs are displacement measurements, they are perfect for relative vibration (positional vibration) measurements. These measurements are made when the physical location of the surface of the vibrating object at any moment in time is a critical factor.

4.2.2.5 Additional Capacitive Displacement Sensor Mounting Considerations

Capacitive displacement sensors have a measurement “spot size” about 130% of the diameter of the sensing area of the probe. If the measurement target area is smaller than this it will be susceptible to errors and may require special calibration.

4.2.2.6 Multiple Capacitive Probes

When multiple capacitive probes are used with the same target, their drive electronics must be synchronized. Lion Precision multi-channel capacitive sensor systems (Elite Series and CPL230) use synchronized electronics. Capacitive sensors require no minimum distance between adjacent probes.

4.2.2.7 Environmental Considerations for Capacitive Sensors

Capacitive sensors require a clean, dry environment. Any change in the material between the probe and target will affect the measurement.

All sensors have some sensitivity to temperature, but Lion Precision capacitive sensor systems are compensated for temperature changes between 20°C and 35°C with a drift of less than 0.04%F.S./°C.

Ordinary changes in humidity have no effect on capacitive displacement measurements. Humidities into the 90% range can begin to affect the measurement; any condensation in the measurement area will render the measurement invalid.

4.2.2.8 Additional Eddy-Current Displacement Sensor Mounting Considerations

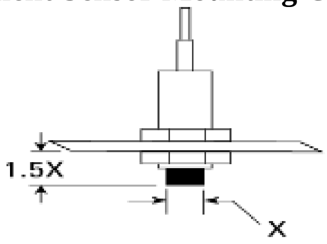


Fig 4.16 Eddy current displacement sensors (horizontal mounted)

Eddy-Current displacement sensors use a magnetic field that engulfs the end of the probe. As a result, the "spot-size" of eddy-current displacement sensors is about 300% of the probe diameter. This means any metallic objects within three probe diameters from the probe will affect the sensor output.

This magnetic field also extends along the probe's axis toward the rear of the probe. For this reason, the distance between the sensing face of the probe and the mounting system must be at least 1.5 times the probe diameter.

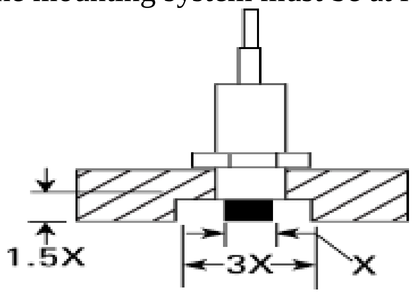


Fig 4.17 Eddy current displacement sensors (vertical mounted)

4.2.2.9 Multiple Eddy-Current Probes

When multiple probes are used with the same target, they must be separated by at least three probe diameters to prevent interference between channels. If this is unavoidable, special factory calibrations are possible to minimize interference.

4.2.2.10 Environmental Considerations for Eddy-Current Sensors

Linear displacement measurements with eddy-current sensors are immune to foreign material in the measurement area. The great advantage of eddy-current non-contact sensors is that they can be used in rather hostile environments. All non-conductive materials are invisible to eddy-current sensors. Even metallic materials like chips from a machining process are too small to interact significantly with the sensors.

4.3 FAULTS INTODUSED IN GEAR AND BEARING AND ITS METHOD

4.3.1.1 Scoring: Scoring is a type of abrasive wear, referring to a rough surface, usually with cuts. It appears as long scratches in the direction of motion. This process is caused by lack of adequate lubrication under extreme pressure.

4.3.1.2 Pitting: Pitting is a surface fatigue failure of gear tooth. It occurs due to repeated loading of tooth surface and contact stress exceeding the surface fatigue strength of the material. Material in the fatigue region gets removed and a pit is formed.

4.3.1.3 Corrosive wear: Corrosive wear occurs due to accumulation of moisture in atmospheric oxygen, the particles of lubricant undergoes oxidation on the surface of the gear which reduces the strength of material by forming rust or layer.

4.3.1.4 Abrasive wear: Abrasive wear is the scratching or gouging of active gear tooth surfaces resulting in creation of metal wear. It is caused by insufficient lubrication, or by contaminants within the lubrication.

4.3.1.5 Excessive wear: This is wearing that has continued to be a problem until a significant amount of material has been affected on the surfaces. You may see pitting on the surface with excessive wear, typically caused by not seeing the first wear early enough, and it continues to progress.

4.3.1.6 Frosting: This issue usually shows up in the dedendum area of the driving gear. The wear pattern gives a frosted appearance, which are many micro pits on the surface. Frosting is a common issue when the heat breaks down the lubrication film

4.3.1.7 Spalling: Although it is similar to severe pitting, the pits tend to be shallow and larger in diameter. Additionally, the area that is showing spalling does not tend to be uniform. It is a common problem when high contact stress exists.

4.3.1.8 Breakage: It is possible for the entire tooth or a piece of the tooth to break away. It often leaves evidence of the focal point of the fatigue that led to the break, which results from any number of issues, including high stress or excessive tooth loads.

4.3.1.9 Bending fatigue: Bending fatigue occurs over time in response to repetitive loading. Over time, this loading can lead to microscopic cracks in the gear, followed by crack propagation perpendicular to the area with the highest load, and finally, a fracture to the gear. You'll noticed concentric "beach marks" where bending fatigue is occurring.

4.3.1.10 Contact fatigue: Contact fatigue, sometimes called Hertzian fatigue, happens when repetitive, direct stresses cause abrasions or otherwise deteriorate the integrity of the gear. Contact fatigue can occur as micro pitting, less than 1 mm in diameter, or macro pitting, more than 1 mm in diameter.

4.3.1.11 Scuffing: Scuffing is essentially a severe form of adhesion wear, when metal from one gear tooth transfers to another over time

Gears can be classified by shape as involute, cycloidal and trochoidal gears. Also, they can be classified by shaft positions as parallel shaft gear, intersecting shaft gears.

4.3.2 Methodologies to identify the faults introduced in both gears and bearing.

4.3.2.1 Visual Inspection

Visual monitoring can sometimes provide a direct indication of the machine's condition without the need for further analysis. The available techniques can range from using a simple magnifying glass or low-power microscope. Other forms of visual monitoring include the use of dye penetrants to provide a clear definition of any cracks occurring on the machine surface, and the use of heat-sensitive or thermographic paints.

4.3.2.2 Vibration Analysis

Modern condition monitoring techniques encompass many different themes; one of the most important and informative is the vibration analysis of rotating machinery. Using vibration analysis, the state of a machine can be constantly monitored and detailed analysis may be made concerning the health of the machine and any faults which may arise or have already arisen. Machinery distress very often manifests itself in vibration or a change in vibration pattern. Vibration analysis is therefore, a powerful diagnostic and troubleshooting tool of major process machinery.

4.3.2.3 Temperature Monitoring

Temperature monitoring consists of measuring of the operational temperature and the temperature of component surfaces. Monitoring operational temperature can be considered as a subset of the operational variables for performance monitoring. The monitoring of component temperature has been found to relate to wear occurring in machine elements, particularly in journal bearings, where lubrication is either inadequate or absent.

4.3.2.4. Acoustic Emission Analysis

Acoustic emission refers to the generation of transient waves during the rapid release of energy from localized sources within a material. The source of these emissions is closely associated with the dislocation accompanying plastic deformation and the initiation or extension of fatigue cracks in material under stress. The other sources of acoustic emission are melting, phase transformations, thermal stress, cool-down cracking, and the failure of bonds and fibers in composite materials.

4.3.2.5. Noise Analysis

Noise signals are utilized for condition monitoring because noise signals measured at regions in proximity to the external surface of machines can contain vital information about the internal processes, and can provide valuable information about a machine's running condition. When machines are in a good condition, their noise frequency spectra have characteristic shapes. As faults begin to develop, the frequency spectra change. Each component in the frequency spectrum can be related to a specific source within the machine

4.3.2.6 Wear Debris Analysis

It is not possible to examine the working parts of a complex machine on load, nor is it convenient to strip down the machine. However, the oil which circulates through the machine carries with it evidence of the condition of parts encountered. Examination of the oil, any particle it has carried with it, allows monitoring of the machine on load or at shutdown. A number of techniques are applied, some very simple, other involving painstaking tests and expensive equipments.

4.3.2.7 Motor Current Signature Analysis

Motor current signature analysis (MCSA) is a novel diagnostic process for condition monitoring of electric motor-driven mechanical equipment (pumps, motor-operated valves, compressors, and processing machinery). The MCSA process identifies, characterizes, and trends overtime the instantaneous load variations of mechanical equipment in order to diagnose changes in the condition of the equipment..

4.3.2.8. Nondestructive Testing

The principle of nondestructive testing (NDT) is to be able to use the components or structure after examination. The inspection should not affect the item involved, and must therefore, be nondestructive. NDT includes many different technologies, each suitable for one or more specific inspection tasks, with many different disciplines overlapping or complimenting others. Thus the best technique(s), for any one application, should be decided by an expert eddy current testing, electrical resistance testing, flux leakage testing, magnetic testing, penetrant testing, radiographic testing, resonant testing, thermographic testing, ultrasonic testing, and visual testing are some of the different NDT techniques.

NOTE: Out of all the methodology mentioned above for identifying faults introduced for gears and bearings .Vibration analysis method is actually best method.

REASON:

1.Vibration is the most employed for the reason that every machine is considered to have a normal spectrum until they have fault, where the spectrum changes

2.Vibration have been proven effective to reflect the health condition of the rotating machinery.

4.4 DIFFERENT LUBRICATION ANALYSIS

4.4.1 Wear debris analysis

It is a technique for analyzing the debris, or particles, present in lubrication oil that could indicate wear, particularly mechanical wear. This method provides microscopic examination and analysis of debris/particles found in a lubrication oil. These particles consist of metallic and nonmetallic matters.

4.4.2 Particle analysis methods

The main aspects of wear debris analysis are quantitative figures and qualitative facts. Regarding the qualitative aspects of debris, color, shape, and texture is important. As the first step, the morphology of wear particles should be examined visually by a trained expert. After that the computer scanning and image recognition should be applied..

4.4.3 Colour and characteristics of particles

Colour of particles and debris is an important feature in the wear debris analysis. If the shape and texture allow one to differentiate the wear particles according to their prehistory of formation, colour may help to define debris composition or other useful data. Composition of wear particles is determined by the materials of worn surfaces, contaminants, and products of chemical reactions

4.4.4 Particle size and shape

The sizing is one of the important aspects of the wear debris study. Three parameters — average particle size, maximum particle size, and the particle size distribution — are important. As a rough indication, the damage state of machinery could be proportional to the size of the particles. This is definitely true for some machinery items such as gear units. As an indication, the following size classification is presented for wear debris analysis:

- fine: less than 5 microns
- small: less than 20 microns
- medium: 20-50 microns
- large: above 50 microns.

4.4.5 SOA

Spectrometric oil analysis (SOA) reveals the chemical composition of metal particles suspended in the oil samples. By comparing the results to the known chemical composition of various machinery parts, abnormal wear of machinery parts can be identified, and servicing of the machinery can be initiated, thus sometimes avoiding further costly repairs or even catastrophic failure.

4.4.6 Wear particles

Sliding adhesive wear particles are found in most lubrication oils. They are usually an indication of normal wear. They are produced in large numbers when one metal surface moves across another. The particles are seen as thin asymmetrical flakes of metals with highly polished surfaces.

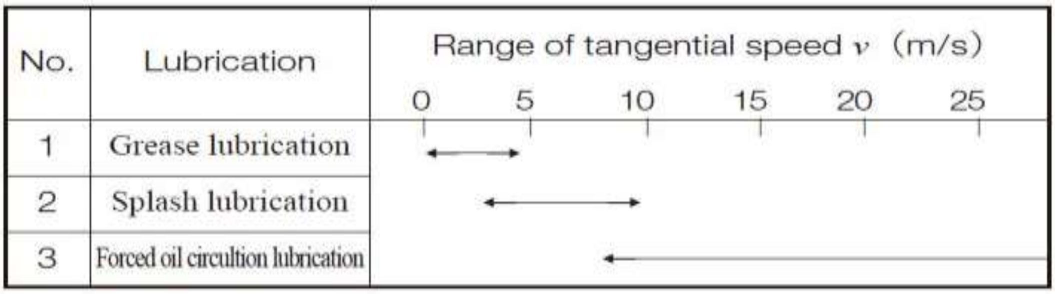
4.5 Methods of Lubrication

There is no single best lubricant and method. Choice depends upon tangential speed(m/s) and rotating speed(rpm). At low speed, grease lubrication is a good choice. For medium and high speeds, splash lubrication and forced oil circulation lubrication are more appropriate, but there are exceptions. Sometimes, for maintenance reasons, a grease lubricant is used even with high speed. Below table presents lubricants, methods and their applicable ranges of speed. Grease lubrication can be applied in low speed / low load applications, however, it is important to apply grease periodically, especially for gears of the open-type usage

Table 4.3 Ranges of tangential speed (m-s) for spur gears and bevel gears

No.	Lubrication	Range of tangential speed v (m/s) 0 5 10 15 20 25
1	Grease lubrication	
2	Splash lubrication	
3	Forced oil circultion lubrication	

Table 4.4 Ranges of sliding speed (m-s) for worm wheels



The following is a brief discussion of the three lubrication methods.

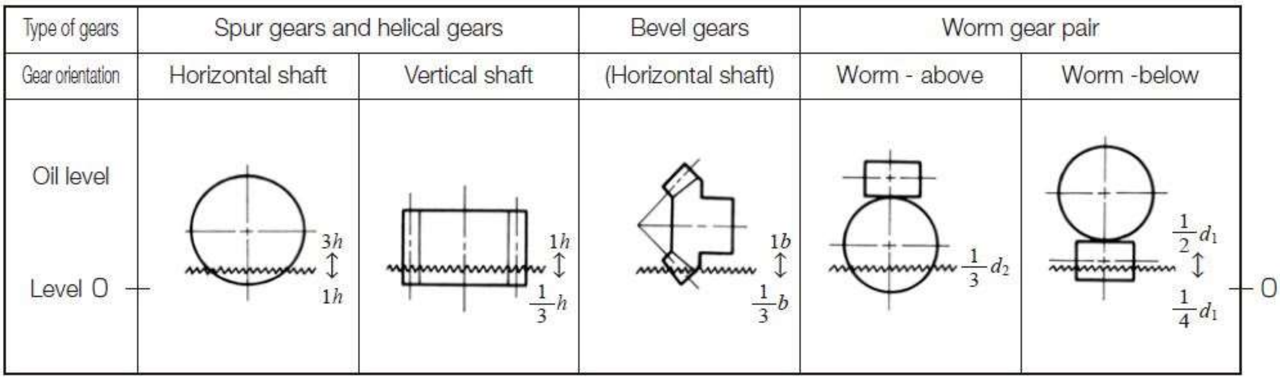
(1) Grease Lubrication Grease lubrication is suitable for any gear system that is open or enclosed, so long as it runs at low speed. There are three major points regarding grease:– Choosing a lubricant with suitable cone penetration. A lubricant with good fluidity is especially effective in an enclosed system.– Not suitable for use under high load and continuous operation. The cooling effect of grease is not as good as lubricating oil

(2) Splash Lubrication (Oil Bath Method) Splash lubrication is used with an enclosed system. The rotating gears splash lubricant onto the gear system and bearings. It needs at least 3m/s tangential speed to be effective. However, splash lubrication has several problems, two of them being oil level and temperature limitation.

1. Oil level There will be excess agitation loss if the oil level is too high. On the other hand, there will not be effective lubrication or ability to cool the gears if the level is too low. Table 13.2 shows guide lines for proper oil level. Also, the oil level during operation must be monitored, as contrasted with the static level, in that the oil level will drop when the gears are in motion. This problem may be countered by raising the static level of lubricant in an oil pan.

2. Temperature limitation The temperature of a gear system may rise because of friction loss due to gears, bearings and lubricant agitation. Rising temperature may cause one or more of the following problems:– Lower viscosity of lubricant – Accelerated degradation of lubricant– Deformation of housing, gears and shafts– Decreased backlash New high-performance lubricants can withstand up to 80 C deg – 90 C deg.

Table 4.5 Adequate oil level



h = Tooth depth, b = Facewidth, d2 = Reference diameter of worm wheel, d1 = Reference diameter of worm

(3) Forced Oil Circulation Lubrication Forced oil circulation lubrication applies lubricant to the contact portion of the teeth by means of an oil pump. There are drop, spray and oil mist methods of application.– Drop Method An oil pump is used to suck-up the lubricant and then directly drop it on the contact portion of the gears via a delivery pipe.– Spray Method

NOTE (1) Consistency numbers with (1) are classified by viscosity.
REMARKS
1. General use grease in Class 1 consists of base oil and calcium-soap and water-resistance.
2. General use grease in Class 2 consists of base oil and calcium-soap and heat-resistance

5.1 Conclusions

MFDFA delivers a better performance than each of EMD and WT in feature extraction of gearboxes .SVM performs better than each of NN and MDDR in classification of characteristic parameters. Accordingly, the method associating MFDFA with SVM proves reliable in fault diagnosis of gearboxes .

Out of all the methodology mentioned for identifying faults introduced for gears and bearings .Vibration analysis method is actually best method

Reason:

1. Vibration is the most employed for the reason that every machine is considered to have a normal spectrum until they have fault where the spectrum changes

2. Vibration have been proven effective to reflect the health condition of the rotating machinery.

Accelerometer vibration monitoring are best because they are useful for measuring low to very high frequencies and are available in a wide variety of general purpose and application specific designs.

5.2 Scope for future work

- Future enhancement can include further improvement that is for capturing better signal from gear box

- Fault diagnosis using appropriate method

- Lubrication analysis using appropriate method

REFERENCE

1. Condition Monitoring of Ball Bearing Using Vibration Analysis and Feature Extraction S.V.Shelke, A.G.Thakur, Y.S.Pathare #Department of Mechanical Engineering, SRES COE, KOPARGAON &PDVVPCOE,ViladGhat,Ahmednagar Savitribai Phule Pune University,Pune.
2. Failure analysis of the ball bearings of dental airturbine handpieces MWei, JEDyson,BW Darvell Faculty of Dentistry , The University of HongKong, Faculty of Dentistry , Kuwait University , Kuwait .
3. Failure Evaluation of Ball Bearing for Prognostics V.M. Nistane,S.P. HarshaVibration& Noise Control Laboratory, Mechanical& Industrial Engineering Department, Indian Institute of Technology Roorkee, Roorkee—247667,India
4. Methodological approach of selecting a vibration indicator in monitoring bearings O.Djebili1,F.Bolaers1,A.LaggounandJ.P.Dron11Laboratoire Grespi/MANUFR ,Sciences Exactes and Naturelles Moulindela Housse, BP103951687REIMSCEDEX,France.Departmentdephysique,Faculté desSciencesUMBBBoumerdes,Algéria.Accepted5March,2013.
5. Analysis of Single Row Deep Groove Ball Bearing Viramgama ParthD.M.E. (CAD/CAM) Noble Engineering College , Jungadh.
6. Improved 2D model of a ball bearing for the simulation of vibrations due to faults during run-up MatejTadina and Miha Boltezar University of Ljubljana, Faculty of Mechanical Engineering , Askerceva,1000 Ljubljana ,SI-Slovenia.
7. TEST RIG DESIGN AND TESTING PERFORMANCE OF LINEAR BALL BEARING1 KhandareNamdeoRamchandra,Dr.RaghuvirPai, Department of Mechanical & Manufacturing Engineering , MITManipal , India.
8. A review of vibration and acoustic measurement methods for the detection of defects in rolling element bearing N.Tandon ,A. Choudhury ITMMECentre,Indian Institute of Technology , HauzKhas ,New Delhi110016,India Department of Mechanical Engineering , Regional Engineering College,Silchar788010,India Received 5May1999; received in revised form1September1999;accepted 12 October 1999.
9. Vibration Analysis of Ball Bearing Ravindra A.Tarle , NileshK . Kharate, Shyam P.Moga lN.D.M.V.P’sK.B.G.T.C.O.E.,Nashik , Maharashtra,India.

10. .N.G.Nikalaou,I.A.Antoniadis,rollingelementfaultdiagnosisusingwavelet packets,NDT&EInternational35(2002)page197-205.
11. B. Liu, S. Riemenschneider, Y. Xu (2006), "Gearbox fault diagnosis using empirical mode decomposition and Hilbert spectrum", Mechanical Systems and Signal Processing, vol. 20, pp. 718–734.
12. David G. Lewicki, Kelsen E. LaBerge, Ryan T. Ehinger and Jason Fetty (2011), "Planetary Gearbox Fault Detection Using Vibration Separation Techniques", NASA/TM—2011-217127.
13. Dejie Yu, Junsheng Cheng & Yu Yang (2005), "Application of EMD method and Hilbert spectrum to the fault diagnosis of roller bearings", Mechanical Systems and Signal Processing, vol.19, pp. 259–270.