An Overview on Study of Vibration Characteristics of Bearing For The Prediction of Bearing Life

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Abstract- *Bearing play a major role in many dynamic machinery's especially rotary elements, The tribology studies give the insights to the maintenance of bearing, In present work the bearing life is predicted by investigating the vibration characteristics of bearing in dynamic conditions, The frequency response method is used to develop the signatures, And accordingly the service cycles can be predicted for a given bearing.*

Bearing failure is one of the major causes of breakdown in rotating machinery. Failure of bearings can results in costly downtime. Therefore condition monitoring of bearings plays an important role in machine maintenance. In condition monitoring the observed signal is often corrupted by noise during the transmission system. It is important to detect the elementary fault in advance before failure occurs. Therefore it is important to understand the behavior of the occurrence of faults and condition monitoring of the bearings. Among the various methods available for diagnosis and condition monitoring of bearing elements, vibration measurement is the most common one.

Keywords- Bearing life measurement, Vibration Signature, Tribology investigation, Prediction Of Bearing Failure, Understand the Behavior, Frequency Response, Vibration Analysis,

I. INTRODUCTION

A bearing is a machine element which supports other moving machine elements. It permits relative motion between the contact surfaces of the machine elements. Rolling element bearing is vital component for power transmitting systems within the machine tools. Rolling element bearings are used today in the design of increasingly complex arrangements, such as high speed, and high temperature, heavy loadings and requiring continuous operations. A clear understanding of vibrations associated with them is highly needed. There is also a growing tendency that many rotating machines supported by the rolling element bearings,

Source of vibration in any machine is unbalanced, misalignment, faulty gear, and faulty bearing etc. Out of these, the rolling element bearing is the important machine element. If a bearing fails, the whole production line is affected and it will also affect the productivity. Hence it is very crucial to monitored regularly health of the rolling element bearing. The defects arise mostly due to incorrect design, mistaken manufacturing and mounting, misalignment of bearing, improper lubrication, excessive loading, fatigue, wear etc. The defect is parted into two types such as localized defects and distributed defects. Because of fatigue in the rolling element bearing appear wisecracks, small holes, and spall on the rolling surfaces that are such defects is a localized defect. like wisecracks, pits, and spall on rolling surfaces caused by fatigue. The regularly occurring failure is the crack in the bearing races because of the fatigue caused to spread over the bearing surface until a piece of metal separate from the surface creating a small hole. This defect increase if the bearing is loaded too heavily or also existing impact loads during their functioning

The distributed defect is mainly exhibited during mistaken manufacturing, improper assembly, and wear. Bearing frequently develop a localized defect in the raceways, rollers, and cage. The periodic impact is generated when the ball passes upon these defects with the exception of cage defects. This will cause conversion of localized defects into the distributed defects. The contact force differs between the rolling elements (balls) and raceways an accelerating vibration level because of defects. Hence, the study of vibration response for the defective bearing is most important to check the quality of a bearing or condition monitoring.

II. MATHEMATICAL MODEL OF SYSTEM

A bearing is chosen with the end goal that it ought to be effortlessly amassed and disguise. A single row deep groove ball bearing is to be chosen for development of theoretical model according to the low-speed application. A characteristic value such as inner diameter, outer diameter, depth of the groove, could be known. Consider a 2 degree-of-freedom non-linear spring-mass system, in which the outer race is settled in an unbending support and the inner race is settled inflexibility with the motor shaft. Elastic deformation amongst raceways and rolling elements delivers a non-linear phenomenon between force and deformation, which is obtained by the Hertz contact theory.

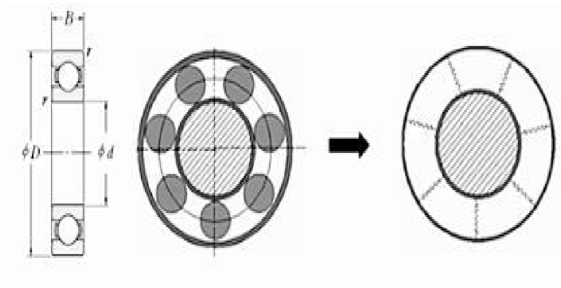


Fig. 1: Rolling element replaced by non-linear spring

While building up the model, the assumptions considered are mentioned below:

1. In the ball bearing model rolling elements (balls) are equispaced.
2. There is no Slipping of the balls.
3. The motion of races and balls present in the plane of the bearing only.
4. The outer race is unbendingly settled with bearing housing.
5. There is no elastic deformation of an inner and outer race.
6. There is no change in temperature of the selected ball be

III. ANALYSIS OF DEFECTIVE BALL BEARING

While developing the numerical model, the defect on the races is represented like a sinusoidal wave. The location of the defect (θ) is at 45 degrees from the X-axis.

An extended defect is spread similarly both sides from the focal point of the defect location. The ball goes through the defect accordingly the additional deflection ($Ddef$) for the travel of the ball in the defective region of the outer race can be determined,

$$Ddef = Ra*\sin(\pi/\varphi)*(\theta i-\theta) \quad)1($$

$$\varphi=Nw*(\omega c*t+\emptyset d*i-1z \quad)2($$

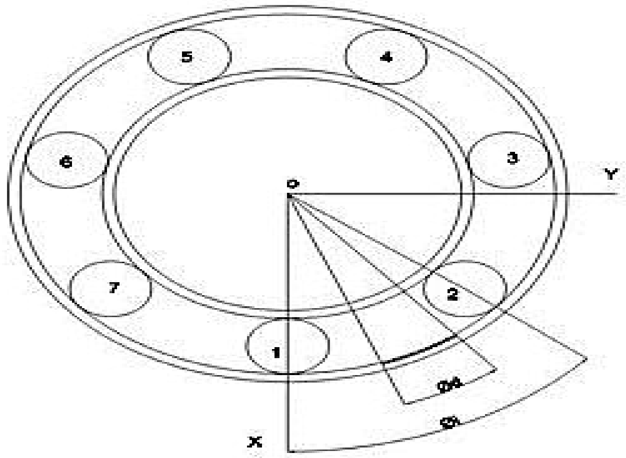
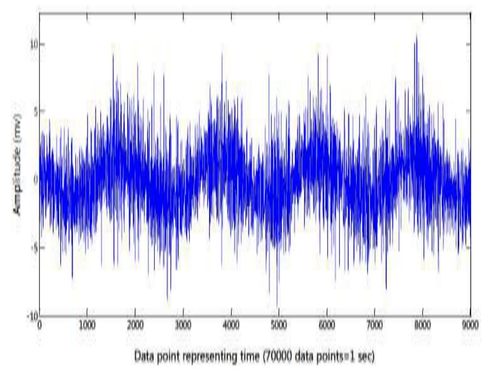


Fig. : Defective ball bearing

IV. TIME DOMAIN ANALYSIS

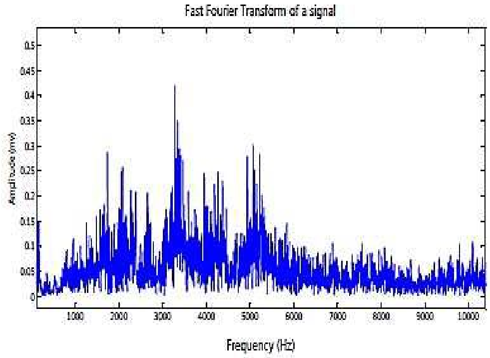
The Measurement of signal energy can be a good indicator of a bearing's health. In time domain analysis the vibration signal are represented in amplitude and time. Statistical parameters (RMS, Kurtosis, Crest factor and(Skewness) are normally used for fault detection in time domain analysis. The overall root-mean-square (RMS) of a signal is a representative of the energy



A typical time domain signal for defect free bearing

V. FAST FOURIER TRANSFORM (FFT)

Fourier transform is a signal processing technique that connects the time domain and frequency domain. In the early 1800's, a French mathematician named Joseph Fourier proved that all waveforms are composed of many individual frequencies which can broke down into their separate components mathematically. This concept is based on the Fourier Integral Fourier analysis has a serious drawback. In transforming to the frequency domain, time information is lost. When looking at a Fourier transform of a signal, it is impossible to tell when a particular event took place.



Typical Fast Fourier Transform (FFT) of a signal

VI. EXPERIMENTAL FACILITIES AND MEASUREMENTS

Experimental setup consists of motor (1- phase 4-pole induction motor), two taper roller bearings, shaft, and V-belt pulley with having three speeds options. The material of shaft is mild steel.

1. Detection of bearings

1. Envelope Detection, the technique for amplitude demodulation is always used to find out the repeated impulse type signals. The ED involves three main steps. First step is to apply a band-pass filter, which removes the large low-frequency components as well as the high frequency noise only the burst of high frequency vibrations remains as shown in Fig.4 (b). In the second step, we trace an "envelope" around the bursts in the waveform (Fig. 4 (c)) to identify the impact events as repetitions of the same fault. In the third step, FFT of this enveloped signal is taken, to obtain a frequency spectrum.

It now clearly presents the BPFO peaks (and harmonics) as shown is Fig. 4 (d).

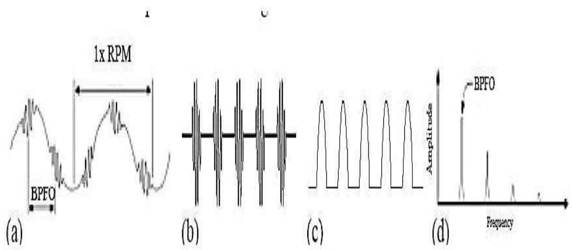
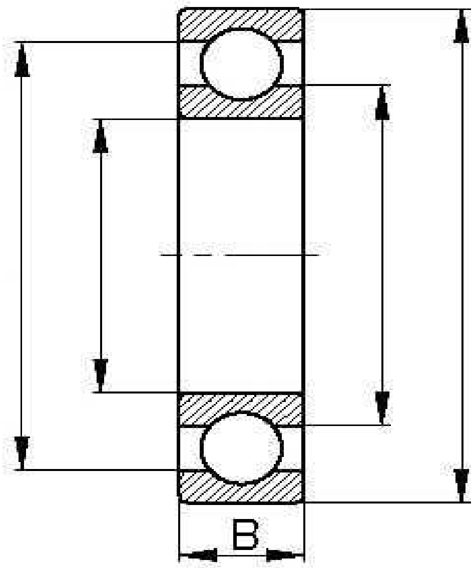


Figure 4. Envelope detection process (a) Unfiltered Time Signal (b) Band passed Time Signal (c) Envelope of Band passed signal (d) Envelope spectrum

Schematic of experimental setup on which experiments were conducted is shown in Figure 6.

VII. SIMULATION ANALYSIS

The shaft-bearing assembly is considered as a mass-spring system and the model also incorporates masses of the balls. Because the system shows a non-linear characteristic under dynamic conditions, the contacts of balls to the inner and outer races are represented by nonlinear contact springs as shown in Fig 1.

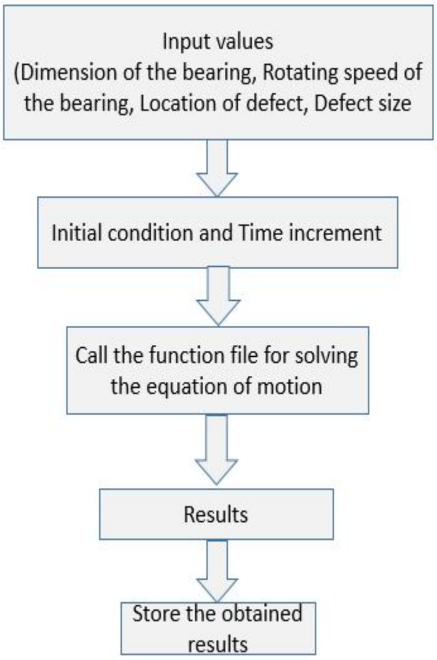


Dimensions of the FAG 6201 type ball bearing and the shaft

VIII. SOLUTION PROCEDURE

For mathematical solutions, the initial conditions and step sizes are very important for progressive and monetary computational solutions. Especially for nonlinear systems, different starting conditions mean an entirely unexpected system and subsequently unique solutions. Improper initial conditions can also cause a larger computation time or sometimes wrong results obtained. The larger the time step, the faster the computation time. Then again, the time step should be small enough to achieve an adequate accuracy. Additionally, little time steps can build truncation errors. In this way, an advancement ought to be made between them. At time t=0 the following assumptions are made:

1. For each ball in the ball bearing considered as same deflection and velocities.
2. Assume the contact stiffness for each ball are same while modeling the solution for the defective and healthy bearing

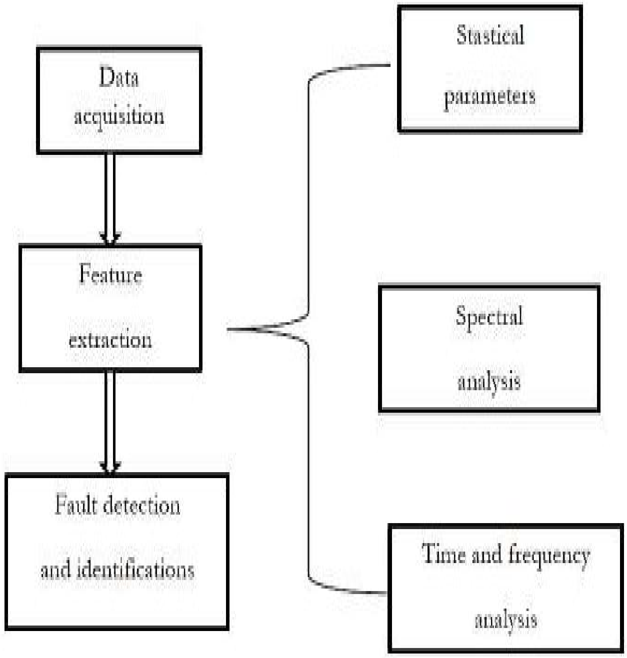


Block diagram of a program

IX. FREQUENCY DOMAIN ANALYSIS

Spectral analysis of vibration signal is widely used in bearing diagnostics. It was found that frequency domain methods are generally more sensitive and reliable than time domain methods. The advent of modern Fast Fourier Transform (FFT) analyzers has made the job of obtaining narrowband spectra easier and more efficient

Frequencies generated in different defective components will add and subtract, therefore some spectrum will contain more than one of the basic frequencies i.e., BPFO, BPFI, BPFB, FTF. In some cases the harmonics of basic frequencies i.e., lx, 2x, 3 x, etc., can be identified in the spectrum. In [Osugawu C. et al. 1982], one reason for the absence of defect frequencies in the direct spectrum was found to be due to the averaging and shift effect produced by the variation of the impact period and inter modulation effect



General vibration fault diagnosis procedure

X. LITERATURE

Many researchers have used vibration signature analysis techniques for rolling element bearing fault identification in case of single defect on bearing components. Time-domain and frequency-domain vibration analysis techniques were tested, but effective identification of bearing condition is, however, not typically straightforward.
Statistical moments recently played an important role in condition monitoring and diagnostics of rolling element bearings, and have attracted the attentions of many researchers. Statistical movements are descriptors of the shape of the amplitude distribution of vibration data collected from a bearing, and have some advantages over traditional time and frequency analysis . Dyer and Stewart first proposed the use of the fourth normalized central statistical moment kurtosis for bearing defect detection. White [studied the effectiveness of this method under a simulated condition. Several other studies have also shown the effectiveness of kurtosis in bearing defect detection. Because of the symmetry of the distribution, odd moments are zero for vibration signals of both healthy and damaged bearings.

XinwenNiu et. al. presented some new statistical moments for the early detection of bearing failure. They found the simulation and experimental tests show that the two new statistical parameters are preferred to the traditional third rectified moment and the fourth moment, respectively. Drona et. have shown the interest of spectral subtraction for the improvement of the sensitivity of scalar indicators (crest factor, kurtosis) within the application of conditional maintenance by vibratory analysis on ball bearings. Furthermore they considered as the case of a bearing in good conditions of use, the distribution of amplitudes in the signal is of Gaussian kind.

XI. CONCLUSION

The present work helps in predicting the life of the bearing by knowing its signatures obtained by vibration frequency response of the bearing ,have selecting the bearing in made cast effective and preventive maintenance can be done, When a local defect grows, it becomes extended one and tends to spread over the track of the bearing race. There is a necessity to implement effective diagnosis of an extended fault in the ball bearing. Hence, the Theoretical model is developed to predict the vibration response of an extended defect in the outer race of the ball bearing. Bearings in rotating machinery should be periodically checked with a frequency spectrum and time signal to detect and study developing defects on the outer and inner races. An accurate method for the calculation of bearing defect length is needed to allow a quantitative determination of the defect severity. With the defect size and progression of development determined, the remaining bearing life can be estimated.

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