A Comparative Study of Various Methods of Bearing Faults Diagnosis- A Review

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Abstract: Bearing plays a vital role in any kind of rotating machinery as bearing failure can put rotating machine in downtime and may interrupt production. So bearing prognosis plays a vital role in estimating the remaining useful life of bearing and hence helps in deciding the right maintenance strategy. The most important factor in doing prognosis is to study the fault growth rate and which is one of the main intent of this paper. In this literature survey study has been carried out on defect propagation of bearing and misalignment of shaft using vibration signature.. Different techniques were used by authors to study crack propagation and misalignment is mentioned in this literature.

Introduction: A bearing is a mechanical device which is used to allow smooth relative motion between two moving part, either linear or rotational movement. Bearings are generally employed where there is contact between the two mechanical parts and a relative motion is required. Bearings are generally divided according to their type of movement, their operational conditions of their applications or the type of loading conditions. Classification of Bearings:

1)Ball Bearings

2)Roller Bearings :

a)Cylindrical Roller Bearings

b)Tapered Roller Bearings

Ball Bearings

Ball bearings use balls as rolling elements between two rings. Ball bearings can support both radial loads (perpendicular to the shaft) and axial loads (parallel to the shaft). For lightly loaded bearings, balls offer lower friction than rollers. Ball bearings can operate even when the bearing races are misaligned.

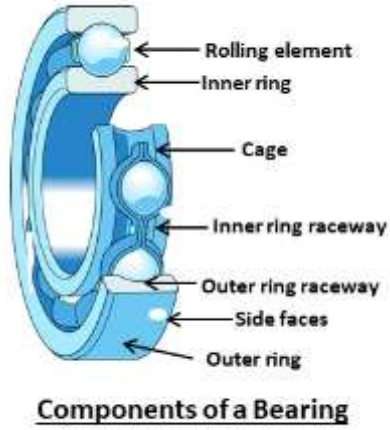

Fig1: Ball Bearing[1]

Roller Bearings

This is another type of rolling element bearing that using cylindrical roller between the inner and outer race of the bearing instead of balls as in the rolling element bearings. Using this type of design the rotational friction is reduced and it can handle more radial and axial loads'

Tapered Roller Bearing

Tapered roller bearings use conical rollers that run on conical races, as shown . Most roller bearings support only radial loads, but tapered roller bearings support both radial and axial loads. They can generally carry higher loads than ball bearings due to greater area of contact.

Cylindrical Roller Bearing

Cylindrical roller bearings, in are similar to ball bearings except that they use a cylinder roller instead of a ball roller. They typically have load capacity higher than the ball bearings

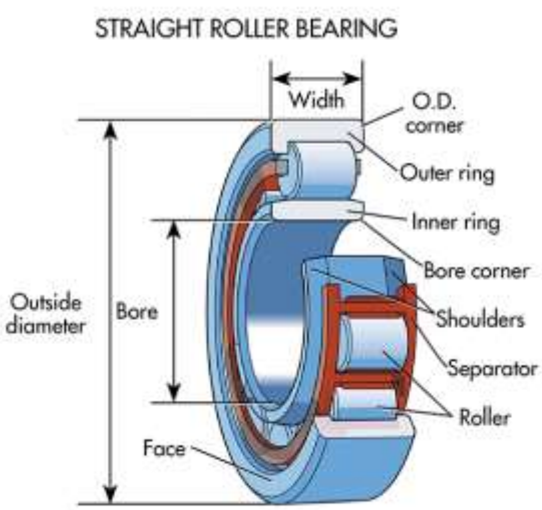

Fig1.2. Cylindrical roller Bearing and Taper roller Bearing[1]

ROOT MEAN SQUARE (RMS)

Root mean square in general measure the overall power content present in the Acoustic/ Vibration signal The power content in the signal is entirely depending upon the value of amplitude which in general shows incrementfor the case of rotating element defect. The mathematical expression for RMS is given by equation [2]

$$RMS = \sqrt{\frac{\sum_{k=1}^{n} x_k^2}{n}} \quad (1)$$

where x_k is amplitude of the signal and n is total number of data points.

STANDARD DEVIATION (σ)

Standard deviation generally measures the dispersion of data from its mean value . The expression of σ is given by equation

$$\sigma = \sqrt{\frac{\sum_{k=1}^{n} (x_k - \bar{x})^2}{n}} \quad (2)$$

where, $\bar{x}$ denotes the average value of amplitude of the signal. In the case of defect, signal yield to have higher values of amplitude and this in consequence creates more deviation from the mean value and hence results in higher value of σ .

SKEWNESS

Skewness is a measure of the lack of symmetry . The Skewness can be expressed mathematically by equation

$$Skewness = \frac{1}{n} \frac{\sum_{k=1}^{n} (x_k - \bar{x})^3}{\sigma^3} \quad (3)$$

The skewness for a normal distribution is zero and hence any symmetric data should have skewness nearly equals to zero. Negative values for theskewness indicate data that are skewed left and positive values for the skewness indicate data that are skewed right to the normal distribution curve. It generally gives the good indication for the cases having the local defects signatures in the form of sharp impulses.[3]

KURTOSIS

Kurtosis is a statistical parameter to measure impulsiveness by measuring peak and tails in a time domain signal. The mathematical expression for kurtosis factor is given by equation :

$$Kurtosis = \frac{\frac{1}{n}\sum_{k=1}^{n}\left[x_k - \bar{x}\right]^4}{\left[\frac{1}{n}\sum_{k=1}^{n}\left[x_k - \bar{x}\right]^2\right]^2} \quad (4)$$

A bearing in good condition has a Gaussian distribution function and the Kurtosis value of its signal is nearly equal to three, but a damaged bearing has a Kurtosis value which will be greater than three . The Kurtosis factor can give information about the overall condition of the machine but not suitable to identify the location type and severity of defect in the complex machine system.

SHANNON ENTROPY(SE)

SE is a measure of randomness in the signal through logarithmic scale. Defect and randomness are directly related as defect creates more randomness in signal and this yield to a higher negative value for the SE.

Kokil et all study the Fault in Rolling Element Bearing using vibration signature analysis. Author study the effect of rotational speed, defect position and load on the rolling element bearing defect. Same set of parameters vibration at outer ring is more as compared to inner ring and outer race defect is more severe then inner race. [4]

Patil and Chappar study the Frequency Response Analysis of Spur Gear for Different Materials. Author uses different material Structural steel, Cast iron and Aluminum alloys etc and recorded the vibration response. It has been found out that maximum stress occur at pitch circle and deddendum and aluminium alloy has less contact stress. Structural steel can be used for high load application. [5]

Patil and Pawar uses Finite Element Analysis Vibration Analysis for Shaft with Gear Mountings author calculate deformation, equivalent stress of shaft when Gear is mounted on it. Author simultes the result uses ANSYS and check whether the design is safe or not under loading. [6]

Patil et all study the effect on Outer Race Of Roller Bearing. Healthy bearing is compared with bearing having a defect on outer race by varying the speed. It has been found out that as defect size increases amplitude acoustic emission amplitude also increases. [7]

Tandon et all proposes the analytical model for predicting the vibration frequency due to defect on outer race inner race and defect on rolling element. Experiment was conducted on 6002 ball bearing. It has been found out that amplitude of outer race defect is quiet high as compare to inner race defect. [8]

Another study was carried out on local and distributed defect by Tandon et all. Presence of defect has been detected by vibration and noise generation. They find out that vibration in time domain can be measured by RMS, crest factor, probability density, crest factor. [9]

Aditya and amarnath carried out on failure analysis on Grease lubricated cylindrical roller Bearing. It has been found out that initially wear rate is constant but when there is misalignment then there is metal to metal contact and wear rate accelerates and it increases the bearing temperature which further reduces the film thickness[10]

Kim and Moon calculated the remaining life of bearing using ISO and stastical method. Predicted life of bearing helps to know when to replace the bearing and avoid sudden failure. [11]

Sui and zhang proposes wavelet transform and morphological filters for detecting the defect in roller element bearing. Morphological filter surpasses the noise in measured signal and helps in detecting the defect. [12]

Vencl et al uses fault tree for tribological failure of roller element bearing. In this author study different types of wear i.eabrasive wear, adhesive wear, surface fatigue wear, erosive wear, fretting wear and corrosive wear etc and their root cause was analyzed. [13]

Mathew and Alfredson uses time domain and frequency domain technique as condition monitoring. It has been found out that when impulsiveness is present in signal kurtosis parameter is very sensitive to respond and when bearing is overloaded time domain technique are not responding. [14]

Poddar and Chandravanshi uses vibration techniques to diagnose and identifydefect on inner race, outer race and ball defect. Author find out BPFI, BPFO and 2xBSF using vibration signature and matches with theoretical value. Defect frequency calculated matches with theorical value. [15]

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