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A Review On Vibration Analysis of Bearing

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***Abstract*: Detection of both localized and distributed categories of defect are considered. In experiments, Faults are introduced on the races and surfaces of test bearings through machining. These bearings are loaded using an electro-mechanical shaker. Results of defects simulation and model behavior in statics and dynamics are calculated and compared.**

***Keywords*: Bearing, Dynamical, Fault, Races, Static.**

1. Introduction

When you submit Rolling contact bearings are used in almost every type of rotating machinery whose successful and reliable operation is very dependent on the type of bearing selected as well as the precision of all associated components, i.e. shaft, Housing, spacers, nuts etc. Bearing engineers generally use fatigue as the normal failure mode, on the assumption that the bearings are properly installed, operated and maintained. Today, because of improvements in manufacturing technology and materials, it is generally the case that bearing fatigue life, which is related to sub-surface, stresses, is not the limiting factor and probably accounts for less than 3% of failures in service. Unfortunately, though, many bearings fail prematurely in service because of contamination, poor lubrication, temperature extremes, poor fitting/fits, unbalance and misalignment. All these factors lead to an increase in bearing vibration and condition monitoring has been used for many years to detect degrading bearings before they catastrophically fail (with the associated costs of downtime or significant damage to other parts of the machine).

Rolling element bearings are often used in noise sensitive applications, e.g. household appliance electric motors which often use small to medium size bearings. Bearing vibration is therefore becoming increasingly important from both an environmental consideration and because it is synonymous with quality.

It is now generally accepted that quiet running is synonymous with the form and finish of the rolling contact surfaces. As a result, bearing manufacturers have developed vibration tests as an effective method for measuring quality. A common approach is to mount the bearing on a quiet running spindle and measure the radial velocity at a point on the bearing’s outer ring and in three frequency bands, viz. 50-300, 300-1800 and1800-10000 Hz. The bearing must meet RMS velocity limits in all three frequency bands. Vibration monitoring has now become a well-accepted part of many planned maintenance regimes and relies on the well-known characteristic vibration signatures which rolling bearings exhibit as the rolling surfaces degrade. However, in most situations bearing vibration cannot be measured directly and so the bearing vibration signature is modified by the machine structure, this situation being further complicated by vibration from other equipment on the machine, i.e. electric motors, gears, belts, hydraulics, structural resonances etc. This often makes the interpretation of vibration data difficult other than by a trained specialist and can in some situations lead to a mis-diagnosis, resulting in unnecessary machine down time and costs. In this paper the sources of bearing vibration are discussed along with the characteristic vibration frequencies that are likely to be generated.

A. Source of Vibration

Rolling contact bearings represents a complex vibration system whose components – i.e. rolling elements, inner raceway, outer raceway and cage – inter act to generate complex vibration signatures. Although rolling bearings are manufactured using high precision machine tools and under strict cleanliness and quality controls, like any other manufactured part they will have degrees of imperfection and generate vibration as the surfaces interact through a combination of rolling and sliding. Nowadays, although the amplitudes of surface imperfections are in the order of nanometers, significant vibrations can still be produced in the entire audible frequency range (20 Hz – 20 kHz). The level of the vibration will depend upon many factors, including the energy of the impact, the point at which the vibration is measured and the construction of the bearing.

2. Literature Survey

Tandon and Chaudhary [1] explained the review of vibration and acoustic measurement methods for the detection of defects in rolling element bearings. Detection of both localized and distributed categories of defect are considered. They also covered the vibration measurement in both time and frequency domains along with signal processing techniques such as the high-frequency resonance technique. Other acoustic measurement techniques such as sound pressure, sound intensity and acoustic emission are reviewed. Recent trends in research on the detection of defects in bearings, such as the wavelet transform method and automated data processing are given. They are concluded that vibration measurement in the frequency domain has the advantage over time domain because

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it can detect the location of the defect. In recent years' wavelet transform method is used because it extracts very weak signals for which Fourier transform becomes ineffective. Some studies indicate that acoustic measurements are better than vibration measurements and can detect a defect even before it appears on the surface.

Patel et al., [2] have done the theoretical and experimental vibration studies of dynamically loaded deep groove ball bearings having local circular shape defects on either race. In this paper they have developed the mathematical model. The shaft, housing, raceways and ball masses are incorporated in the proposed mathematical model. The results achieved based on the proposed mathematical model have been validated with the experimental results. In experiments, Faults are introduced on the races of the test bearings through electric discharge machining (EDM) and test bearings loaded using an electro-mechanical shaker. Result shows that there is some difference between the theoretical and experimental result of defect frequencies of races. Also vibration enhances in presence of local defects on outer race in comparison to inner race.

M. Dougdag et al., [3], This paper presents an experimental verification of a simplified model of a nonlinear stiffness ball bearing in both static and dynamic modes and testing its capabilities to simulate accurately fault' effects. To verify experimentally the developed model of rigidity in both static and dynamic conditions, a number of compression tests were done on the ball bearings. This requires the specimen grips system adaptation of a mechanical universal testing machine to receive the non-usual specimen. A number of experimental simulations of the main faults are done on a testing bench to verify the defect model. Results of defects simulation and model behavior in statics and dynamics are compared to experimental results. The developed model gives an acceptable similarity and it proves its simplicity and robustness. Both results were acceptable.

Tarle et al., [4] gives the design, experimentation and validation analysis of fault diagnosis of ball bearing related to rotor system. Detail analysis using FFT Methodology is done to find out the possible faults and finally validate with MATLAB software. Numbers of faults are identified and this will be validated for each fault. Faults are identified on single rotor system test rig. Experimental evaluation & validation of faults are done to confirm results and finally effective solution is implemented to completely indicate faults of bearing which are being reported during validation process. In addition to this they have done lubrication analysis by using FFT analyzer for bearing with lack of lubrication and bearing with lubrication.

Kulkarni and Wadkar [5] have analyzed the effect of surface roughness on the vibration response of outer race of the ball bearing. Vibration spectrum produced by the single roughness defect under pure radial load at various locations on outer race of bearing is studied. Effect of roughness size, speed and load on the vibration response is investigated. The experimental results were compared with ball pass frequency of outer race, frequency response obtained from the experimental results is found identical with the theoretical ball pass frequency of outer race and also they found that at constant speed and constant load with different defect sizes on outer ring, amplitudes of vibration vary with increase in the defect size.

Chavan et al., [6] have come across many vibrations related problems of rotating machines where vibration monitoring, analysis and fault diagnosis technique has implemented to detect mechanical faults. This paper gives the importance of vibration monitoring technique and its implementation in sugar industry and also explains some case studies of sugar industry related to bearing vibration problems. The case studies show that whenever looseness is present in the bearing assembly then predominant peak is occurred at 2*RPM of machine. Result shows the whenever bearing fault occurs, there is increase in vibration to higher level.

The early works on mechanical modeling of localized bearing defects was performed by McFadden and Smith [7]. They proposed a vibration models for a single point defect on the inner race of a rolling element bearing under radial load. In this model the vibration is modeled as the product of a series of impulses at the rolling element passing frequency with the bearing load distribution and the amplitude of the transform function, convolved with the impulse response of the exponential decay function. They developed the single point defect model to describe the vibration produced by multiple point defects [8]. These models were experimentally verified by NASA researchers using nonlinear signal analysis techniques.

Sopanen and Mikola [9] proposed a dynamic model for a deep-groove ball bearing including localized and distributed defects, effect of internal radial clearance and unbalance excitation of the system. The model considers the Hertzian contact deformation and elasto hydrodynamic fluid film in rolling contacts. For the modeling purpose, the shape of the defect is described with the length and the height of the defect. The results of their simulation indicates that both inner ring and outer ring defects generates vibration at their nominal frequencies. They also found that the amplitude of the vibration for similar defects is higher for an outer race defect. This is because the outer ring defect is always in the load zone, and thus the pulse occurs every time a ball passes over the defect.

Cao and Xiao [10] presented a dynamic model for double-row spherical roller bearing and studied various surface defects, including localized and distributed ones in their model. The spherical roller bearing systems carries one more extra degree of freedom on the moving race so they formulated the roller inner/outer race contact angles as functions of the axial displacement of the moving race to reflect their dependence on the axial movement. There is an urgent need to study the topological structure and stability of rotor bearing systems with ball bearings. There are a lot of parameters which can act as a source of nonlinearity in these systems such as radial internal clearance and also local surface defects.

Tiwari et al., [11] and Harsha et al., [12] investigated the stability of a rigid rotor supported by deep-groove ball bearings and described the unstable ranges for different radial clearances but the stability of a rolling bearing rotor system containing local surface defects has not been studied before.

3. Conclusion

It is well known that rolling bearings are subjected to various speeds and different loads. This makes bearing subjected to failure which may even cause shut down of machines. In all papers bearings are created with defects in races or surfaces experimentally or numerically and they are subjected to static and dynamic conditions. Their frequency response with speed and time is observed and calculated.

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