A review on taper roller bearing defects using vibration signature

Sumit Shoor
Research Scholar, Lovely Professional University, Phagwara, India,

Manpreet Singh
Department of Mechanical Engineering, Lovely Professional University, Phagwara, India.

Abstract: The life of rotating machines are mainly depended on the working condition of the bearings. Bearing failures leads to putting the machine in breakdown maintenance which leads to create burden on production. If bearing failure could be estimated then these breakdown could be avoided by implication of proper maintenance strategies. .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 aothors to study crack propagation and misalignment is mentioned in this literature.

Key words: Roller bearings, misalignment, defect propagation.

Introduction: 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. 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. Classification of Bearings:

1)Ball Bearings
2)Roller Bearings :
a)Cylindrical Roller Bearings
b)Tapered Roller Bearings

Fig 1: Classification of Bearings[1]

Several authors has worked in field of defect propagation by analyzing different parameters which could help in finding the remaining useful life of rotating equipment's/ machine. This analysis having a key impact while selecting a appropriate strategies for maintenance in reducing downtime.

Singh et al use statistical technique to compare the healthy and defective bearing. Effect of loading is also analyzed on healthy and defective Bearing for comparing healthy and defective bearing acoustic and vibration signal were taken. Time domain techniques like Kurtosis, Standard deviation, Root Mean square and Shannon entropy is used by author. It has been found that among all parameters Shannon entropy shown the trend and if the loading is increased Shannon entropy and standard deviation shown the downward trend which helps to correlate among healthy and defective bearing. Author uses sensitivity index parameter for loading and observed that Shannon Entropy is quick to response in case of defect then standard deviation. [2]

Singh and Kumar uses Motor Current Signature Analysis, Fast Fourier transform, Maximum Relative wavelet energy for Bearing Fault Detection. It has been found out by author that when there is fault then there is change in magnetic field . Author also uses 2D wavelet scalogram in time domain signal and when there is defect then amplitude is increased at predefined frequency [3]

Algule and Hujare study on unbalance in shaft. Author measures the vibrations at different speed and uses FFT (Fast Fourier transform) for detection of unbalance, Mis alignment and crack. It has been found out by author increase in speed cause increase vibration due to increase in centrifugal force. [4]

Baydar andBall uses Vibration Signal in detection of Gear Failures. Defect which are analyzed by author are local faults, broken tooth, gear crack and localized wear. Author uses acoustic and vibration signal for analyzes the defect. Author keep the speed and load constant. It has been found by author that when there is wear on gear tooth a noise is created and increase the amplitude and new energy peak appears observed at a different angular position and which indicates that defect is present. [5]

Nistane and Harsha istudy the defect in bearing subjected to radial load and constatnt speed. . It has been observed by author that any irregularities are noticed in statistical measures, vibration spectra will provide enough information to express position of defect in the bearing. Scalar parameters illustrate damage of ball bearing but they do not provide information about the location of defect. The spectrum analyses are investigated at running test durations in order to envisage defect locations[6]

Shao et al simulated the outer ring defect , inner ring defect and defect in ball bearing. It has been observed that same defect size vibration in outer ring is higher as compare to defect at inner ring. [7]

Tahaand Dung simulates the outer race defect using ABAQUS software and study the vibration signal in frequency domain. Vibration signal of healthy bearing and defective bearing are compared.. It has been found out that amplitude of vibration increases sharply when there is defect and results of FEA are matching with experimental values.[8]

Saruhan and Saridemir et al studies the defect on outer raceway defect, innerraceway defect, ball defect, and combination of the bearing elements using vibration signature and compare it with healthy bearing. Author uses four different speeds and two level of loads. It has been found by author during experimentation that whenever there is defect vibration signature provides enough information hence can be utilize for condition monitoring.[9]

Shrivastava andWadhwani, studies the signal in FFT and time domain for detecting the defect in ball bearings. Defects are created on inner raceway, outer race way and compares with healthy bearing. It has been found out by author that vibration analysis can be used for health monitoring for any machinery and Frequency Spectrum helps to predict the defect on inner race and outer race. Vibration signature provides enough information which helps to find out the defect in roller element bearing. [10]

Tarle and Nilesh et al analysis the anlaysie the vibration signature for defective bearing. Defect was created on outer race and inner race. Results are validated with matlab software. Author also analysis the vibration signal when bearing is lubricated and when there is no lubrication on bearing. It has been found out bu author that amplitude of ball pass frequency multiplier of the outer race (BPFO) is higher then ball pass frequency multiplier of the inner race(BPFI) and amplitude is quiet high when bearing is not lubricated as compared to when bearing is lubricated. [11]

Shaha and Kulkarni simulates rolling element bearing defect using FEA and results are compared with experimental values it has been observed by author that amplitude of outer race defect is more then inner race defect. Simulated vibration pattern has same characteristics as experimental one. It is also observed that as speed increases the peak amplitude value also increases. [12]

Al-Badour and Sunar uses wavelet transform (wavelet and wavelet packet transforms) for analyzing the non-stationary signal of shaft vibrations. In this paper author find out that FFT gives good result in fault detection

for stationary signal and for non-stationary signal wavelet transform yields better result for fault detection. [13]

Babar and Utpat carried out a study on Misaligned Rotating Shaft. Author compares the healthy shaft with misaligned shaft and created a parallel misalignment, Angular Misalignment, and combination of both. RMS value was increased significantly if there is defect. Author also compare the result with FEM and results were found matching so FEM can also be used as tool for analyzing misalignment of shaft. [14]

Misalignment of shaft in coupling was studied by Shekhar and Prabhu. It has been found out that misalignment cause several vibrations. Author developed the Higher Order Finite Element Model. It has been during study that Higher order Element predicts better result for misaligned shaft. Author compares healthy shaft with misaligned shaft and compares the experimental result with FEM. The effect of these misalignments on the vibration response at different speeds was analyzed and find out that amplitude due to bending is very less as compare to the amplitude when shaft was misaligned.[15]

Yu Xing and Hua et al work on misalignment of inner and outer rings and study the angular and Centroidal misalignment between two rings. Author uses Non-Hertzian contact theory to calculate the displacement of inner ring and total contact angle. It has been found out by author that if the misalignment is in support region then the bearing life will reduce and if it is not in support region number of roller subject to load will be increased and roller bearing will become instable. [16]

Study was carried by Hui Ma and Xueyan Zhao et al on loosened bolt and effect was observed on dynamic characteristics of rotor system. Effect of stiffness on lossened bolt and non lossened bolt is also observed with respect to rotational speed. It has been found by author that when stiffness of foundation is less and looseness is more then rotor exhibits very high amplitude or high order magnitude component. But when stiffness of foundation is increased then combined frequency component is observed. Author uses finite element method for simulate the lossened effect. [17]

Singh and Kumar study on vibration analyzes on healthy shaft and unbalanced shaft. Author uses healthy shaft without disk and healthy shaft with an unbalanced Disk and also uses centrally bent shaft without disk and centrally bent shaft with an unbalanced disk. For study of signal author uses Artificial Neural Networks (ANN) and Support Vector Machine (SVM) techniques and features were extracted by using time domain signal techniques. Amplitude of vibration has increased when there is defect. It is also find out by author that if there is fault on rotor and also if the disc is bent then quiet high amplitude is observed at all speed. [18]

Reddy performed a steady state thermal and the effect of Rotational speed on temperature distribution was analyze using Finite element method. It has been found out by author that increase in rotational speed will result in increase in temperature distribution. Further it has been found out that increase in rotational speed

will cause more centrifugal force on inner case of bearing and cause increase in contact stress and deformation.[19]

Viramgama analyze the ball bearing using Finite element analyzes. Author calculate the displacement and stress level under radial and axial load. 3000 N load is applied in radial direction and 4440 N is applied in axial direction using ANSYS. It has been found out that in static condition deformation of bearing is 0.88 mm and maximum stress is 3988 MPA and in dynamic condition the deformation is 1.9 mm and maximum stress generated is 13660 MPA. Hence ANSYS can be utilize to selectthe optimum parameters .[20]

Conclusion : In industries the bearing is subjected to varies loading conditions. The defect in the bearing could propagate differently for different loading conditions .In this literature survey study has been carried out on defect propagation on bearing and misalignment of shaft using vibration signature. . Several author uses different techniques to study the defect propagation and misalignment of shaft is mention in literature

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