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Vibration Studies of Deep Groove Ball Bearing Considering Single and Multiple Defects in Races

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ABSTRACT: A dynamic model of deep groove ball bearing is coupled with the motor. At different speed, different load condition the experimental results conducted. Defect is generated on the races of deep groove ball bearing with the help of EDM, & this bearing is experimental tested by frequency spectrum analysis in the FFT analyser. This experimental results compare with the characteristics ball pass frequency formulas.

KEYWORDS: vibration, frequency domain, deep groove ball bearing, FFT analyser.

I. INTRODUCTION

Ball bearings are widely use in small as well as big industrial machines. Performances of such machine are greatly influence by quality of bearings used in it. In spite of perfect geometry of ball bearing, vibrations are commonly generated through the interaction of the rolling element during the motion. There are many localized defects are generated during bearing operation, which are pits, spalls etc. Most of the engineering applications such as electric motors, bicycles and roller skates use these bearings, which enable rotary motion of shafts apart from complex mechanisms in engineering such as power transmissions, gyroscopes, rolling mills and aircraft gas turbines. In general ball bearings are made of four different components, an inner ring, an outer ring, the ball element and the cage. The cage element helps in separating the rolling elements at regular intervals and also it holds them in place within the inner and outer raceways to allow them to rotate freely. In order to prevent bearing failure there are several techniques in use. Such as, oil analysis, wear debris analysis, vibration analysis and acoustic emission analysis. Among them vibration and acoustic emission analysis is most commonly accepted techniques due to their ease of application. The time domain and frequency domain analysis are widely accepted for detecting malfunctions in bearings. [4]

Rolling element bearings are indispensable mechanical components which permit shafts to rotate with the highest precision together with very low friction provided bearing has no fault. When, however, a fault develops on either one or all of the raceways of a bearing, stability of the shaft deviates from the intended motion, and resulting bearing vibration level increases. When the fault is not detected at its early stage, the fault further develops and may damage the other components of the machine in question and finally catastrophic failures may result, which causes loss of time, money, and production. As a result, detection of bearing failures and, consequently, taking preventive measures by applying efficient maintenance strategy play a vital role for the continuation of production [12].

Vibration measurements of rolling element bearings and its meaningful analyses play vital role in faults detections. For preventing losses in industries, defects detection in bearings at their early stages is essential issue. The local defects on races rolling elements of bearings generate series of impulses due to interaction of the defects with bearing elements during operations. Due to weak defective bearing signals, the defect frequency of bearing may not be clearly visible in the conventional Fast Fourier Transform (FFT) of vibration signals. As the load carrying members, the rolling element bearings are very critical for safe and efficient operation of the rotating mechanical systems .However, it is undeniable that the use of bearings always brings some non linearity to the mechanical systems, and the important causes for non linearity are the radial clearance between rolling elements and raceways, and the nonlinear restoring forces between various curved surfaces with defects in contact [14] .

The proposed work is concerned to vibration study of deep groove ball bearing having single point and multi point defects in bearing outer surface of inner race and inner surface of outer race. The effect of multiple local defects on inner and outer races of bearing is analyzed by frequency spectrum.

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II.LITERATURE REVIEW

The rolling elements bearings are widely used in industrial and domestic machines. The existence of even tiny defects on the mating surfaces of the bearing components can lead to failure through passage of time. Their failure leads to economical losses. The vibration monitoring technique is mostly used in the industries for health monitoring of bearings. From a review of dynamic models of healthy and faulty rolling element bearing it has been observed that the vibration amplitude of the defective bearing are more compare to the healthy bearing. Moreover, the presence of bearing fault (local or distributed) and its location can be identified through the time and frequency domain analysis of the vibration signal. In this connection a literature review is conducted and the research issues are declared.

Singh and Howard [1]

In this paper focused on a review of literature concerned with the vibration modeling of rolling element bearings that have localized and extended defects. An overview is provided of contact fatigue, which initiates subsurface and surface fatigue spalling, and subsequently leads to reducing the useful life of rolling element bearings. To investigate the effects on the vibration characteristics of defective rolling element bearings, a full parametric study could be conducted that could include a matrix of parameters, which can be varied. These parameters may include load (both radial and axial) on a bearing, rotational speed, clearance within a bearing, and various defect types. The types of bearing defects may range from line, to area, to extended area spalls having different profiles of surface roughness, which can be made similar to operational defects observed in real-world applications.

Shaha [2]

Studied the rolling bearing, with outer ring fixed, is a multi body mechanical system with rolling elements that transmit motion and load from the inner raceway to the outer raceway. Modern trend of Dynamic analysis is useful in early prediction. Dynamic analysis has become a very powerful tool for the betterment of the actual performance of the system. The methodology for prediction and validation of dynamic characteristics of bearing rotor system vibration is studied. The proposed simulation method is used to determine the vibration signal response for various shaft speeds and loading condition, which is compared with experimental result. It is found simulated vibration pattern has similar characteristic compare to experimental results. The deviation in amplitude of acceleration is may be due to variation of mesh density in the region near to defect and also deviation in frequency occurs due to uncontrolled parameters during experimentation.

Viramgama [3]

Focused on increased usage and the increased sophistication mechanical design came to necessity to predict their endurance capability. In this project an effort has been put to analyze the ball bearing using finite element analysis the stress level or displacement behavior of ball bearing. The main target is to find the most influencing parameters for radial stiffness of the bearing under an axial load. The life of bearing we get is in the multiple. So we can conclude that our bearing is safe against the radial and axial load which is applied at static and dynamic condition.

Manjunath and Girish [7]

Analysed the performance of polymer ball bearings made with Polyacetal (POM) material. Ball bearings are widely used in industry from home appliances to aerospace industry. Proper functioning of these machine elements is extremely important in order to prevent catastrophic damages. It is therefore, important to monitor the condition of the bearings and to know the severity of the defects before they cause serious catastrophic damages. Hence, the study of vibrations generated by these defects plays an important role in quality inspection as well as for condition monitoring of the ball bearing machine element. This paper describes the vibration analysis technique to detect the defects in the ball bearing. The Fast Fourier Transform (FFT) detected the frequencies of damage present during the vibration analysis of a ball bearing.

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Patel et al. [8]
This paper focused on theoretical and experimental vibration of dynamically loaded deep groove ball bearings having local circular shape defects on either race are reported in this paper. The shaft, housing, raceways and ball masses are incorporated in the proposed mathematical model. Simulated and experimental results pertaining to vibration of bearing housings are compared and discussed. When a ball approaches to the inner race defect, the additional displacement of the ball changes from zero to maximum, while, it reaches to zero from its maximum value when ball reaches from the centre of the defect to the other end of the defect.

Tandon et al. [11]
In this paper the experiments has been carried out using a test rig for capturing the vibration signals of test bearing. The external vibration has been imparted to the housing of the test bearing through electromechanical shaker. In envelope analysis the centre frequency has been selected using the spectral kurtosis for the filters length of 32 and 64 for different bandwidths. Through this study, it has been revisited and confirmed that the defect detection in envelope analysis mainly depends on the selection of centre frequency and bandwidth. The spectra of selected centre frequency with several bandwidths have been studied and compared for identification of defective frequency.

Li-xin et al. [12]
This paper analyzed of the bearing joint has been modelled by introducing a nonlinear constraint force system, which takes into account the contact stiffness interaction between the rolling elements and the raceways. The proposed model has been applied in the dynamic simulations of a planar slider–crank mechanism with a deep groove ball bearing joint. A general methodology for dynamic modelling and simulation of planar multimode systems containing the deep groove ball bearings with clearance was presented and discussed throughout this work. The bearing joint used is modeled by introducing a nonlinear constraint force system, which takes into account the contact stiffness interaction between the rolling elements and the raceways.

Patel et al. [14]
Focused on a dynamic model is reported herein for the study of vibrations of deep groove ball bearing having the single and multiple defects on the surface of the inner and the outer race. The mass of housing, shaft, races and balls are considered in the dynamic model. Comparison of vibration spectra for the cases having single and two defects on races reveals relatively higher velocity amplitudes with two defects. Good correlations between theoretical and experimental results are observed. Characteristics defects frequencies and its harmonic are broadly investigated using both theoretical and experimental results are observed.

III. OBJECTIVES

1. To analyse vibration response of rolling element bearing in rotor bearing system to a local defect under radial load.

2. To analyse the frequency domain when single point in the races of the deep groove ball bearing by using frequency spectrum .

3. To analyse the effect of defect on the deep groove ball bearing when the different radial load is acting.

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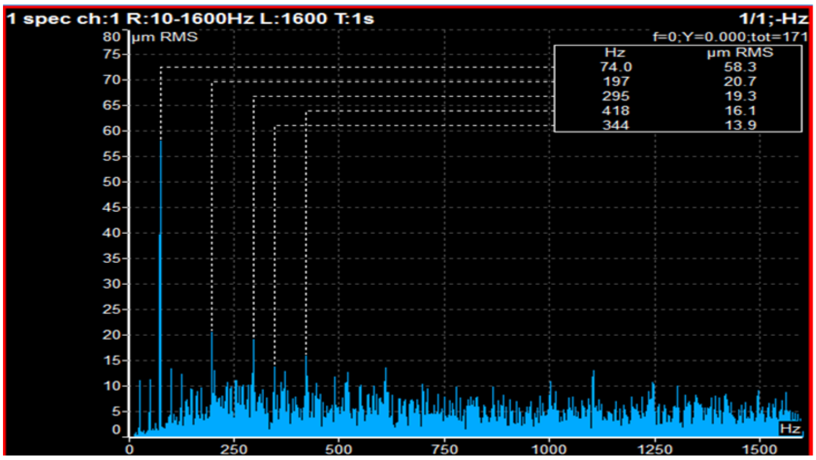
IV. EXPERIMENTAL SETUP

Fig. 1. Experimental Setup: Test rig of Defect detection analysis of Deep Groove Ball bearing

VI. ANALYSIS

1.Deep groove ball bearing with single defect on Outer Race



2.Deep groove ball bearing with single defect on Outer Race

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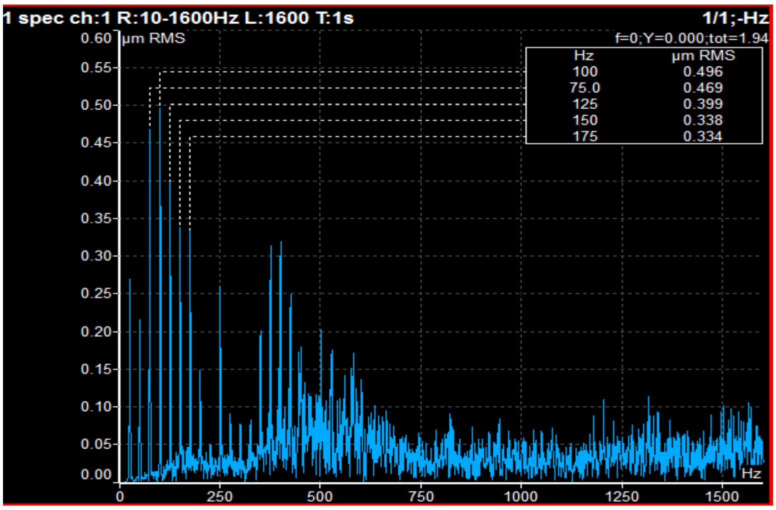

OUTER BALL PASS FREQUENCY(BPFO)

- **BPFO =[(Nb/2) * (Ns/60) * (1-d/D)]**
  =[(8/2) * (1440/60) * (1- 8.7/37.9)]
  = 73.96 Hz.

INNER BALL PASS FREQUENCY (BPFI)

- **BPFI =[(Nb/2) * (Ns/60) * (1+d/D)]**
  =[(8/2) * (1440/60) * (1+8.7/37.9)]
  = 118.03 Hz.

- **COMPARISION OF CHARACTERISTICS DEFECTIVE FREQUENCY**

DEFECT LOCATION	**SIMULATED RESULTS**	**EXPERIMENTAL RESULTS**
DEFECT ON OUTER RACE	BPFO = 73.96 Hz	BPFO = 74.0 Hz
DEFECT ON INNER RACE	BPFI = 118.03 Hz	BPFO = 100.0 Hz

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