

Analysis of Deep-Groove Ball Bearing using Vibrational Parameters

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ABSTRACT: Bearing is an indispensable element of almost any rotating machinery. These bearings in due course of time undergo damage which may be confined to inner race, outer race, ball, cage, or all of these. Using various state of the art technologies like Vibration Analysis, Shock Pulse Method, and Acoustic Emission, these bearing faults can be identified, without dismantling the machine. Among all these vibrational analysis of bearing signature is a classical technique. This study differs from the others due to the load carried by the bearing. In practice, the load applied is with some eccentricity and produces unbalanced force on bearing. The vibration response from ball bearing due to the change in mass, eccentricity for loading and with varying speed is found experimentally by using FFT analyser. This paper presents an experimental study of bearing vibration and application of FFT spectra as a smart tool for diagnosis and identification of bearing faults like inner race defect, outer race defect and ball defect.

KEYWORDS: Vibrational Signal, FFT spectra, Ball bearing, Ball defect, Inner race defect, Outer race defect

I. INTRODUCTION

This investigation on the dynamic behavior of ball bearings was motivated by the demand for silent bearings in noise-sensitive applications, especially in the household appliance and automotive industry. The present investigations are intended to provide a clear understanding of the role of the bearing in the application with respect to its design, its quality and the way in which it is mounted in the housings.

Ball bearings can be important generators of noise and vibrations in applications. Due to the rotation of the lubricated contacts, the stiffness in the bearing is time dependent and generates parametric excitations. Furthermore, vibrations are generated by geometrical imperfections on the individual bearing components.

Nowadays, the lifetime and load capacity of these bearings is fairly well controlled thanks to the availability of new materials and improved production processes. As a result of these developments, noise is increasingly becoming the decisive parameter that determines the bearing quality.

Bearing is an indispensable element of almost any rotating machinery and as such bearings play a critical role in safe and reliable operation. Frequency of bearing failure is high in any machinery as compared to its other components and hence they are often responsible for the machine breakdown. In fact the majority of the maintenance capital expenditure is spent on bearings. Bearing faults if detected at an early stage can prevent such failures and reduce downtime of equipment. In the last few decades many state of the art technology like vibration measurement, shock pulse method and acoustic emission techniques have been developed.

This paper focuses on vibration measurement technique and use of Fast Fourier Transformation (FFT) to obtain vibration amplitude versus frequency spectra for the study of bearing fault

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frequencies to detect and characterize different bearing faults. Knowing the frequency of the vibration is paramount in diagnosing the problem. This is especially true for bearing.

II. LITERATURE REVIEW

A complex bearing dynamic models was developed, by P.K. Gupta using the generalized equations of motion for the rolling elements, cage, and raceways. The dynamic models include effects such as roller-race interaction, roller-cage interaction, cage –raceway interaction, lubricant drag and churning, roller skew, cage instabilities, material properties of the bearing components, operating conditions such as speed, load, misalignment and preloads. His models were capable of handling geometrical imperfections such as variations in rolling element size, race curvature, and bearing element imbalance and cage geometry, allowing various bearing defects to be simulated. However, experimental verification of the results has not been undertaken except for limited examples [1]-[4].

McFadden and Smith developed have a single-mode vibration model to explain the appearance of various spectral lines owing to different defect locations in the demodulated spectrum. They have suggested that the sidebands around the defect frequency are a result of the modulation of carrier frequency by loading and transmission path [9]–[12].

This model has been extended by Su and Lin to characterize the vibrations of bearings subjected to various loadings [13].

Martin and Thorpe have suggested normalization of the envelope-detected frequency spectra of the faulty bearing with respect to the healthy bearing to give greater sensitivity to the detection of defect frequencies [14].

Acoustic Emission Techniques and Shock Pulse Method are another two techniques being widely used for bearing fault diagnosis .The use of this technique traces back to 1969 when Balerston used it for the defect diagnosis of rolling element bearings and proposed the acoustic emission (AE) source mechanism [15].

Acoustic Emission (AE) refers to the generation of transient elastic waves produced by a sudden redistribution of stress in a material. When a structure is subjected to an external stimulus (change in pressure, load, or temperature), localized sources trigger the release of energy, in the form of stress waves, which propagate to the surface and are recorded by sensors.

The early research pretending to shock pulse method is by Boto. The Shock Pulse method involves measuring the shock signal on a decibel scale. He developed a simple model of the contact action when a ball encounters a spall and measured the energy released during the impact [16].

However these techniques have very recently become popular, with the advent of researchers like Hawman and Galinaitis have carried some research on acoustic emission monitoring of faulty bearing[17].Tandon has worked on statistical methods of bearing fault diagnosis including RMS, crest factor, kurtosis, statistical methods, and probability density function[18].

Mba,D., Raj, B. K., and Rao have carried out extensive research on the development of Acoustic Emission Technology for Condition Monitoring and Diagnosis of Rotating Machines: Bearings, Pumps, Gearboxes, Engines, and Rotating Structures[19].

III. THEORY

Ball bearings are required to overcome the speed deference between a rotating shaft and its surrounding structure. A common ball bearing consists of a number of rolling elements and two rings, the inner and the outer ring.

Both rings have grooves or raceways to guide the rolling elements. The rolling elements are separated from each other

by a cage. To reduce the friction and wear in the rolling contacts, bearings are lubricated with oil. The part of the surrounding structure that is connected to the bearing is usually referred to as the housing. The bearings and the housings have to provide sufficient static support for the shaft.

When a bearing spins, any defect or irregularities in the raceway surfaces or the rolling elements such as indentation, spalls, crack, flaking or irregularities in roundness of the rolling element excites periodic frequencies called fundamental defect frequencies. A machine with a defective bearing can generate at least five frequencies [4].

These frequencies are:

1. *Rotating unit frequency or speed (f)*: This is the frequency at which shaft on which bearing is mounted rotates. It is expressed in RPM, cycle per second (cps) or hertz (Hz)
2. *Fundamental train frequency (FTF)*: It is the frequency of the cage. FTF seldom appears in vibration spectrums as the train hardly carries any load.
3. *Ball pass frequency of the outer race (BPFO)*: It is the rate at which the ball/roller passes a defect in the outer race
4. *Ball pass frequency of the inner race (BPFI)*: It is the rate at which a ball/roller passes a defect in the inner race. The level of BPFI is often slightly lower than BPFO as the vibration is generated further away from the transducer.
5. *Two times ball spin frequency (2 X BSF)*: It is the circular frequency of each rolling element as it spins. When one or more of the balls or rollers have a defect such as a spall (i.e., a missing chip of material), the defect impacts both the inner and outer race each time one revolution of the rolling element is made. Therefore, the defect vibration frequency is visible at two times (2X) the BSF rather than at its fundamental (1X) frequency.

IV. RESULT

In order to determine the defect in deep groove ball bearing for the corresponding static condition we had perform easily using computers by Using ANSYS software.

We had perform test on ANSYS Software to analysis steady loading and response conditions are assumed; that is, the loads and the structure's response in which vary slowly with respect to time to study so we did in Static Structure which determines the displacements, stresses, strains, Factor of Safety, Life and Damage had been analysed for 2000N and 5000N.

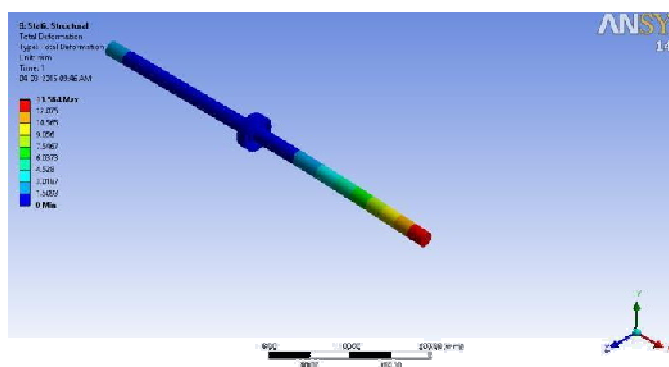


Figure: 1 Static Structure Deflection for -2000N (Y direction)

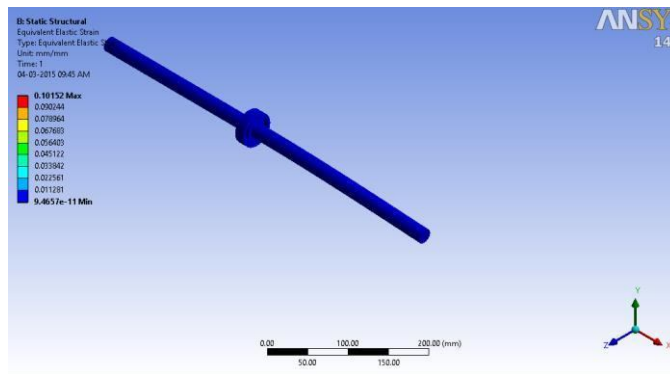


Figure: 2 Static Structure Strain for -2000N (Y-direction)

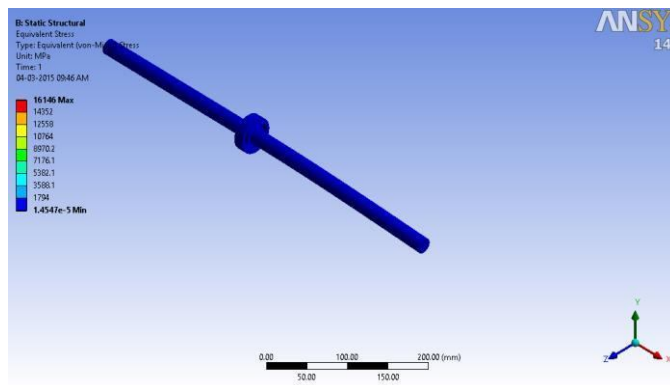


Figure: 3 Static Structure Stress for -2000N(Y-direction)

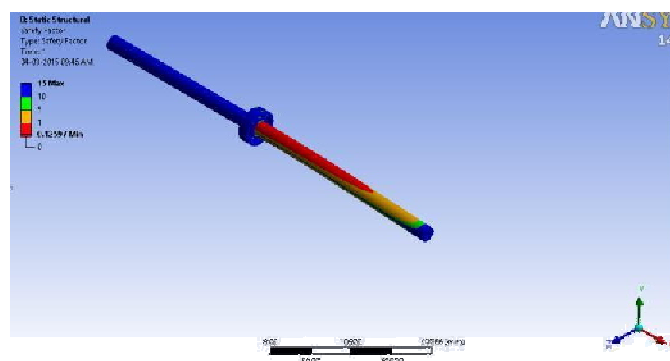


Figure: 4 Static Structure Factor of Safety for -2000N (Y-direction)

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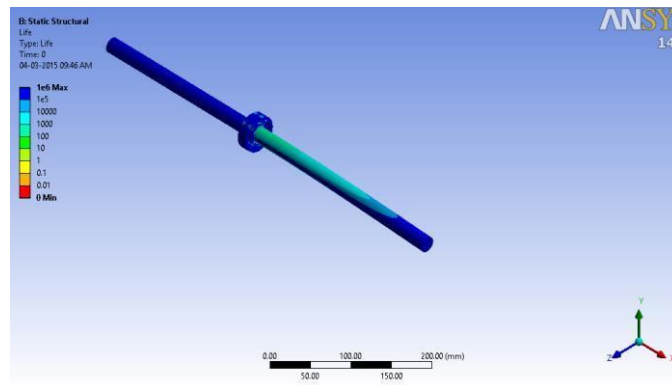


Figure: 5 Static Structure Life for -2000N (Y-direction)

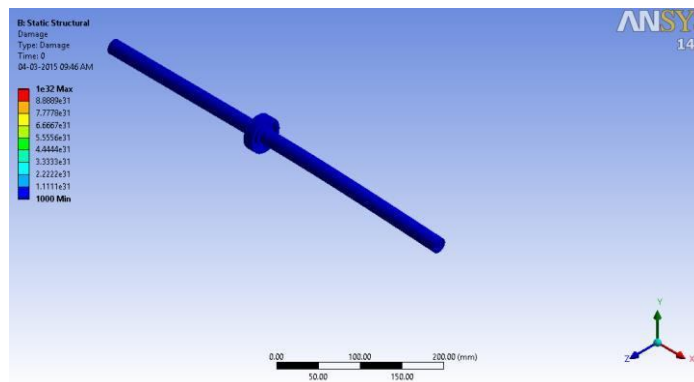


Figure: 6 Static Structure Damage for -2000N (Y-direction)

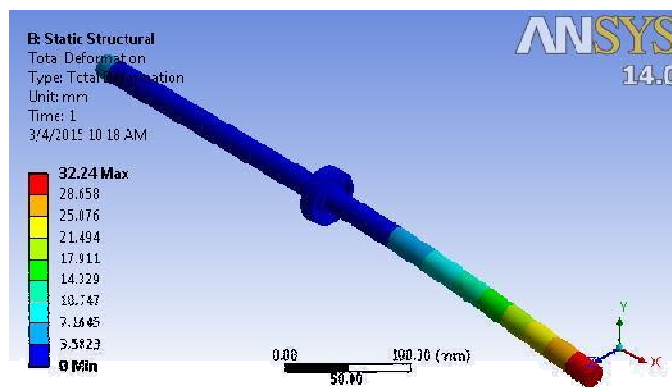


Figure: 7 Static Structure Deflection for -5000N (Y-direction)

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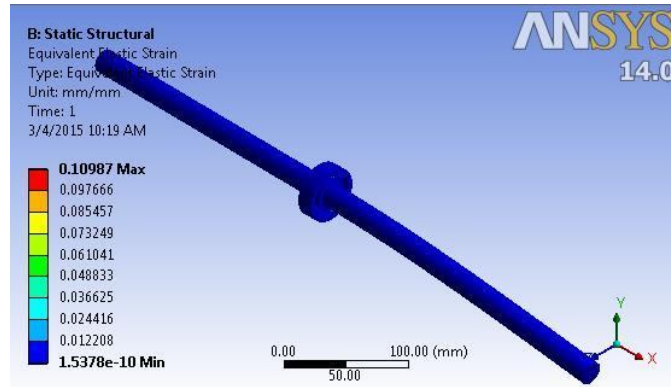


Figure: 8 Static Structure Strain for -5000N (Y-direction)

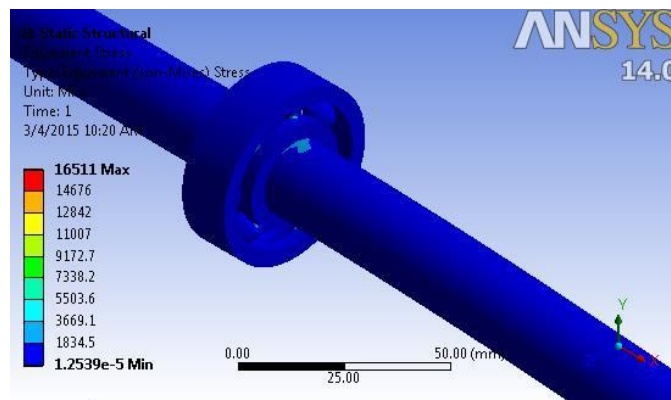


Figure: 9 Static Structure Stress for -5000N (Y-direction)

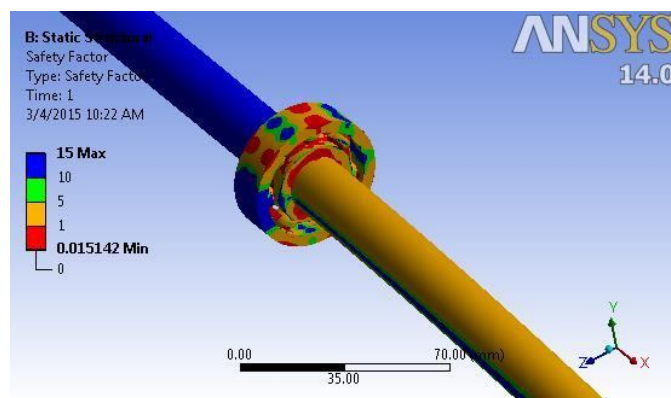


Figure: 10 Static Structure Factor of Safety for -5000N (Y-direction)

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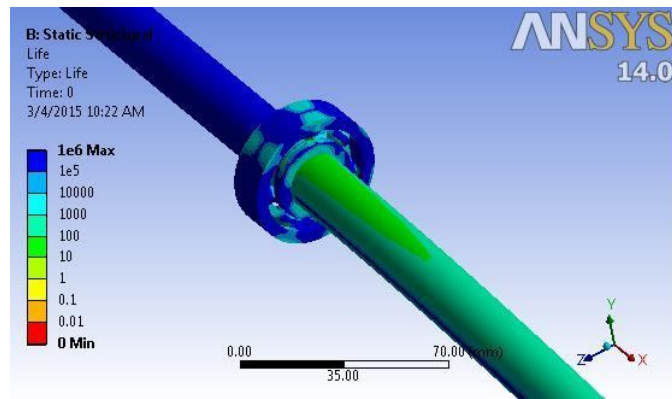


Figure: 11 Static Structure Life for -5000N (Y-direction)

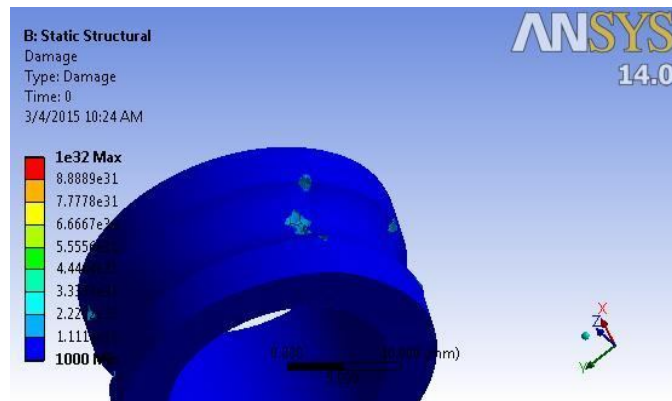


Figure: 12 Static Structure Damage for -5000N (Y-direction)

We had perform test on ANSYS Software to determine the natural frequencies and mode shapes are important parameters in the design of a structure for dynamic loading conditions, so we performed Modal Analysis, and Harmonic analysis had been analysed for 2000N and 5000N.

We produced result for vibration occurred in shaft, inner race, outer race, and retainer and also to ball.

Harmonic Analysis for obtained frequency from Modal Analysis for -2000N (Y-direction)

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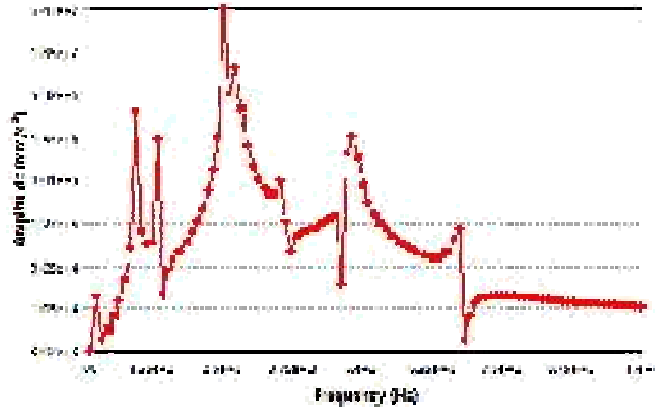


Figure: 13 Harmonic Response: Shaft -2000N (Y-direction)

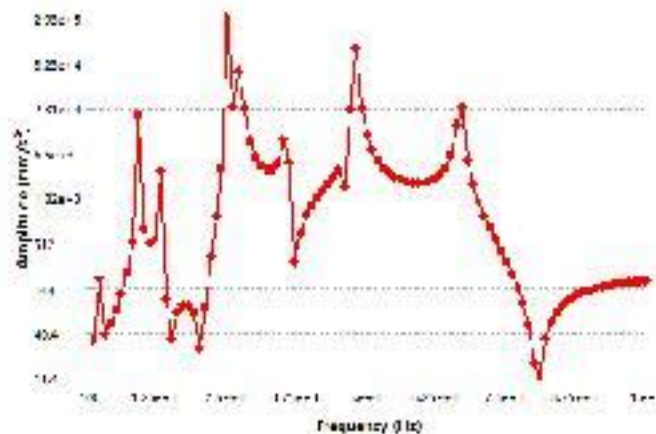


Figure: 14 Harmonic Response: Outer Race -2000N (Y-direction)

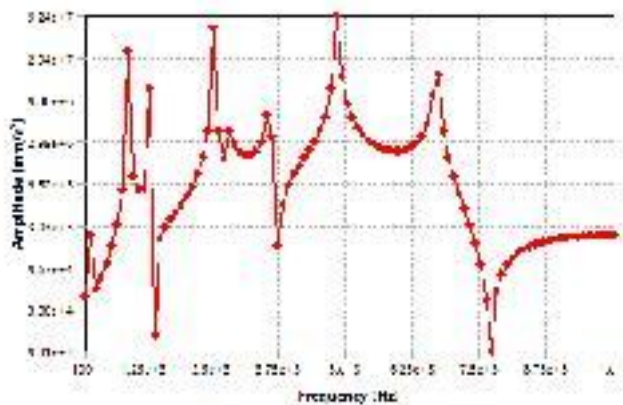


Figure: 15 Harmonic Response: Ball -2000N (Y-direction)

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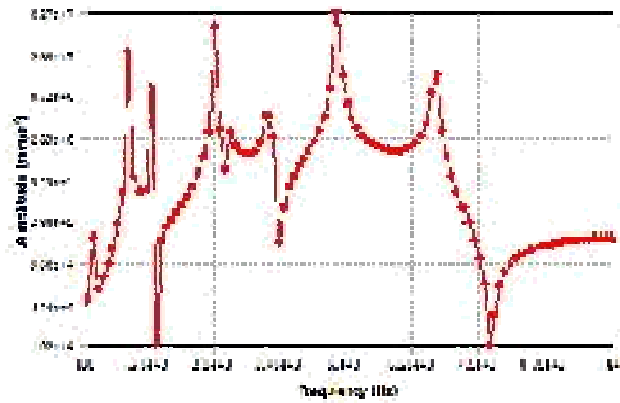


Figure: 16 Harmonic Response: Retainer -2000N (Y-direction)

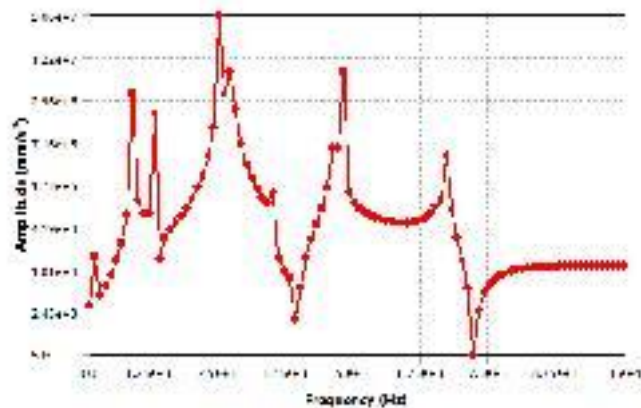


Figure: 17 Harmonic Response: Inner Race -2000N (Y-direction)

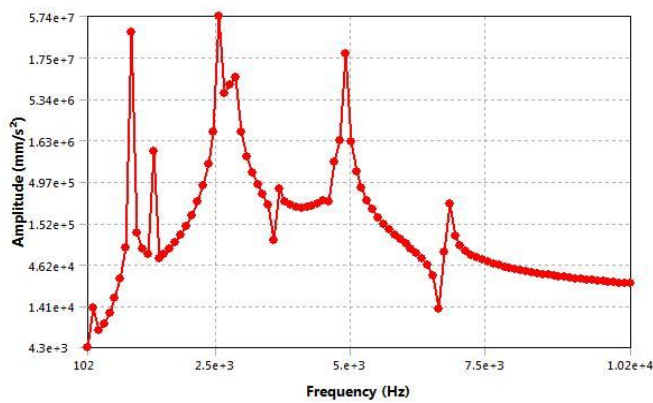


Figure: 18 Harmonic Response: Shaft -5000N (Y-direction)

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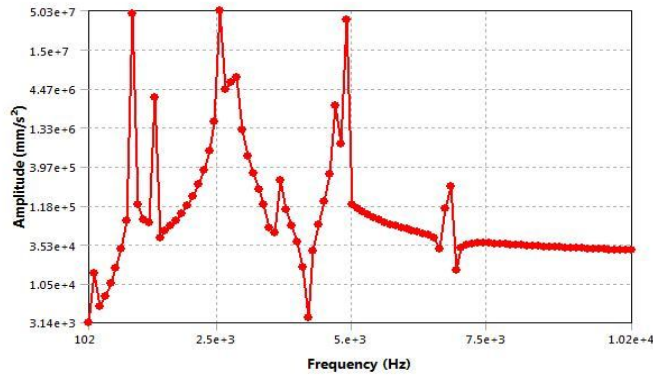


Figure: 19 Harmonic Response: Inner Race -5000N (Y-direction)

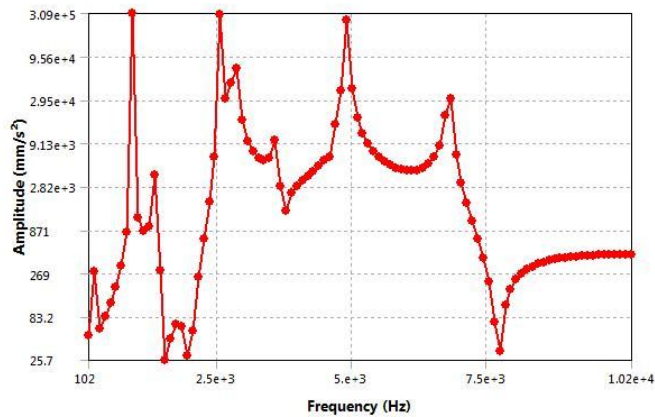


Figure: 20 Harmonic Response: Outer Race -5000N (Y-direction)

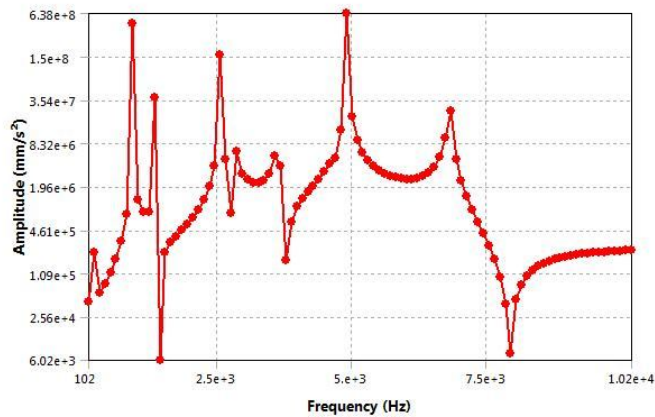


Figure: 21 Harmonic Response: Retainer -5000N (Y-direction)

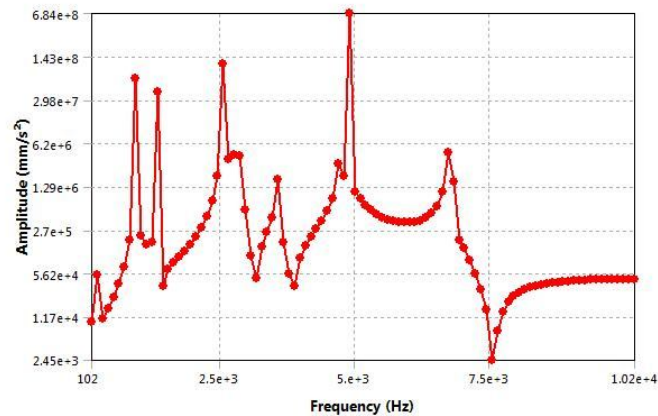


Figure: 22 Harmonic Response: Ball -5000N (Y-direction)

V. EXPERIMENTAL SETUP

We are going to do further investigation of Dynamic analysis in real time so we are going perform experimental test at Sri Venkateswara College of Engineering, Pennalur, where there is vibrational Accelerometer setup will be using in this research work. This is a versatile setup for studying signatures of common machinery faults. Its robust yet flexible design allows for easy installation and removal of bearings and loaders. The setup has a Single phase AC High Speed motor (2800 rpm) to provide smooth range of speeds as per the demand and suitability of particular experiment.

IV. CONCLUSION

The objective of this research was to study FFT spectrum of faulty ball bearing having three different defects-inner race defect, outer race defect and ball defect. The harmonics of shaft rotating frequency and side band around bearing shows that some looseness and misalignment was there in setup. The amplitudes of those peaks are high, however under permissible limits as per the ISO Machinery Vibration Severity Chart has to be maintained. There is difference in -2000N load and -5000N load had been analysed and static load has to be maintained according.

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