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Investigation of Deep Groove Ball- Bearing Vibration Behavior &Effect of the Bearing Life

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Abstract
Investigation of Mechanical systems like Lathes, Motors, Pumps, Turbines, and Engines are the rotating machines are relying. Misalignment, unbalance, rotor cracks and rotor rubs, all the measurements are done at the bearing locations. Earlier bearings themselves having so many rotating elements, they themselves could be defective. This is the main cause for only bearing system consideration by neglecting the other parameters. Anti-friction bearings are the elements that will allow or transmits the motion with smoothness. Finding the defects in the bearing is very difficult sometimes. Present work includes how the rise of vibration will affect the bearing life and also how could fault will be initiated with corresponding to load at the constant speed. SKF 6024 Bearing is considered for this work and Experimentation has been done by varying the load radially from zero to maximum constant speed. The outer race is fixed in this work and carried the dynamic loading with the help of a hydraulic press. The data has been captured by CSI Emerson device and found the fault root cause with the help of Fast Fourier transformation in frequency domain analysis.

Keywords: *Spectrum Analysis, Vibration Level, VFD Pump, Bearing life, frequency domain analysis.*

I. INTRODUCTION

Several parameters can measure while operating the equipment like pressure, temperature, flow, velocities, etc. However, of knowing these parameters, the vibration signature has the information. Generally, vibration is started as it is a response to some form of excitation.

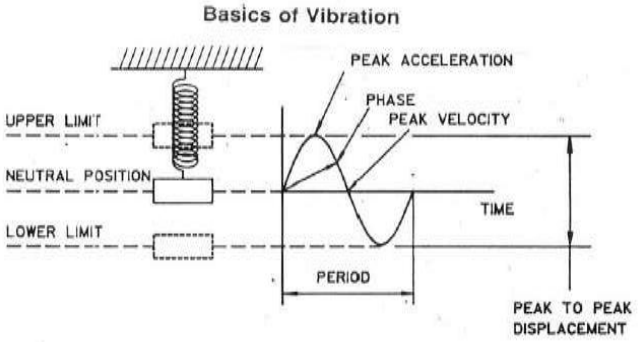

Figure1: Basics of vibration

1.1 Condition Monitoring Techniques

The condition monitoring technique is employed for noting significant changes in the machinery. From the changes we can find the development of fault. It is a predictive maintenance technique. There are many predictive maintenance techniques, including:

1.2 General Steps in a Vibration Monitoring

Steps to be pursued to accomplish an effective vibration-observing project. The means are

1.2.1 Collect valuable Data – Look, tune in and feel the apparatus to check for deficiencies underlying driver like reverberation. Distinguish the estimations that are required. Is to be led for

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additional data.

1.2.2 Analyze unearthly data – Compare generally speaking pattern esteems in various ways with past information.

1.2.3 Different-parameter observing – current examination, increasing speed encompassing, stage estimations, oil investigation, and thermography might be utilized.

1.2.4 Perform Root Cause Analysis (RCA) – To distinguish the genuine reasons for the issue and to keep them from reoccurring.

1.2.5 Reporting and arranging activities – Use a Computer Maintenance Management System (CMMS) to take care of the issue and make a move to accomplish the objective.

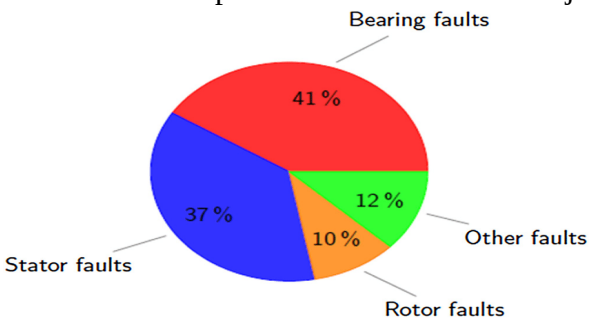

Figure2: Reporting and planning actions

1.3 Signal Processing Techniques

The condition checking framework contains signal handling methods. There are various kinds of shortcomings. The preparing of these sign is significant. The choice of the proper strategy relies upon the idea of the caught sign. These strategies are, Time-space investigation: Time area examination requires the investigation of physical sign, as for time. A period space chart is utilized for finding the adjustment in a sign as for time.

Frequency space examination: Frequency area investigation includes the examination of physical sign, as for frequency. It shows the quantity of sign existing in the given frequency.

Time-Frequency space investigation: It contains the strategies utilized in both the time and frequency areas at the same time. This investigation is comprised of this includes the investigation of the two-dimensional sign. Vibration must be estimated legitimately as for machine segment (or) with the packaging .yet the vibration might be seen in the time area as a frequency space. For simple and precision investigation consistently go with the frequency space. The waveform of sine wave contains the other part flag moreover which are close to the observed hardware like Belts, Bearings, fans, impellers, and so on. This prompts complex waveform and changed into a range it is exceptionally hard to break down. Utilizing FFT: A mind boggling sine wave is separated into a progression of individual sine waves as appeared in the chart.

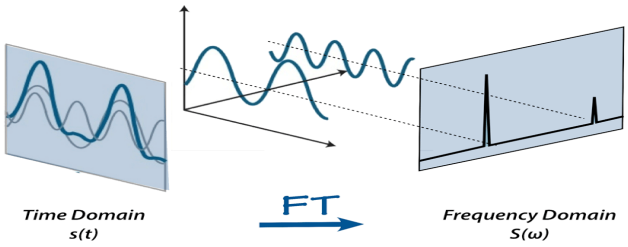

Figure3: Experimentation set up

Here the pinnacles will show up in the recurrence area where the wellspring of an issue appeared in recurrence Sources of vibration in Rotating Machine element. Many papers are accessible for shortcoming identification by utilizing vibration strategies. They are three kinds of approaches to be specific, the Time-space approach, Frequency area approach and Time-Frequency area approach [1]. In 2018, Vibration-based Fault Diagnosis Techniques for Rotating Mechanical Components: Described the condition observing procedures in detail and Fault Detection and Diagnosis utilizing vibration with signal preparing strategies [2]. In 2016, examined the deformities of spike gear like ill-advised chamfering and setting abandons by utilizing the recurrence space system. Vibration signals are taken from the 2-organize spike gearbox by utilizing the FFT procedure to get the

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frequencies signals, which uncovers the flaws. At long last found the deficiency at tooth by utilizing FFT yet it doesn't portray seriousness [3]. In 2016, built up a system for finding the flaw in a 2-arrange helical gearbox by utilizing the propelled sign handling method with the assistance of both Acoustic Emission and Vibration estimation. Removed the demonstrative qualities from the discrete waveform with an inventive wavelet highlight. It uncovers the acoustic discharge was discovered more than the Vibration recording of early analysis of characteristic wear in gear frameworks [3]. In 2015, Analyzed the belt drive utilizing the Vibration checking strategy to read for the sound and flawed running states of a framework. Three assortments of shortcomings were presented in the framework. The flaws are side-cut-in, side-pattern and free and side-cut-out. By differing the speed from 540RPM to 1000RPM. The working velocity of the belt impacts the recurrence of the belt drive. The power of the vibration is straightforwardly relative to with the expansion of the RPM. The free and side-cut-out condition is found at the most extreme degree of vibration [5]. In 2015, have recognized the Bearing Faults and Controlled the Vibrations by utilizing Vibration Analysis. Has discovered the bearing issues in both engine and fan bearing areas because of the issue of misalignment by utilizing range examination in the recurrence space [6]. watched Fault conclusion of Ball orientation by measurable investigation. This is accomplished by vibration examination and exploring diverse time-space parameters. Vibration information of sound bearing are utilized as a standard for the examination of vibration spectra of the defective bearing [7].On Bearing Health Condition Monitoring Time Domain Analysis. The work centers around the Time Domain Analysis in Vibration Analysis of a moving contact component bearing. This investigation relies upon a few factual highlights, which are utilized to distinguish the deficiency in the bearing component done by an element extraction technique. It includes figuring the highlights by utilizing the crude vibration sign to discover the highlights with the Time information [7]. Concentrate on Vibration-Based Condition Assessment of rolling component Bearings with Localized Defects. In their investigation, the vibration reaction of the moving direction to the deformities on the external race, internal race, and the moving components was examined. [9].On Bearing Fault Analysis Using Frequency Analysis. Bearing imperfection finding is significant. Early issue discovery in apparatus can spare a huge number of rupees in crisis. In their paper, they clarify the strategy for recognizing bearing issues utilizing FFT and by utilizing Wavelet investigation all the more explicitly HAAR wavelet up to two degrees of approximations and detail parts. The examination is completed disconnected in MATLAB [10]. In 2011 have introduced Fault conclusion in gear utilizing a wavelet envelope control range. The deficiencies in vibration signals are identified utilizing wavelet investigation. The indicative capacity of the FFT control range and the wavelet envelope control range are analyzed by utilizing test information. They are registered utilizing Laplace and Morlet wavelet works separately.

The above investigation prompts focus on the range examination and comprehends the seriousness of shortcoming to main driver the issue. Additionally urged to consider the bearing issues discovery and how vibration prompts decline the bearing life.

II. EXPERIMENTAL SETUP

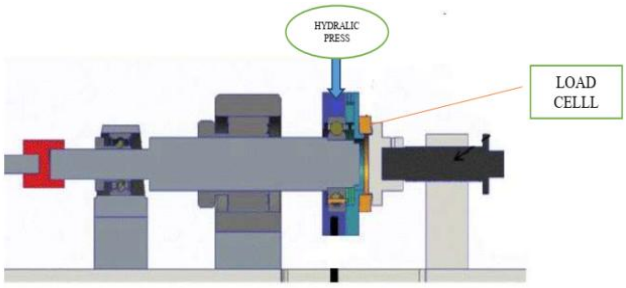

Figure 4.The front view of the experimental setup

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Load cell:

A load cell is a transducer, explicitly a power transducer. It changes over a power, for example, pressure, weight, strain, or torque into an electrical sign that can be estimated and institutionalized. As the power applied increments on the load cell, the electrical sign changes relatively. Loads are included the bearing radially by utilizing the water driven press, the speed sensor is utilized to gauge the vibration perusing. The loads are applied to the bearing in a step by step expanded way and the vibration information noted in the table with the particular load. Taken the load readings with huge vibration distinction for bearing life figuring. The schematic graph and measurements are pursued.

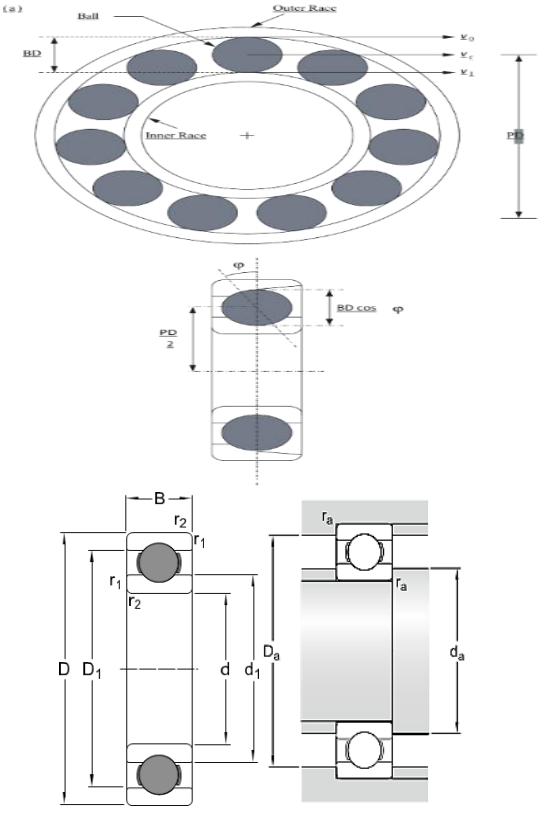

Figure5: Schematic diagrams of SKF Bearing 6024

Table1: The dimensions of an SKF 6024 deep groove ball -bearing

d		120	mm
D		180	mm
B		28	mm
d_1	≈	139.05	mm
D_2	≈	165.3	mm
$r_{1,2}$	min.	2	mm
d_a	min.	129	mm
D_a	max.	171	mm
r_a	max.	2	mm

Table2:The different parameters of an SKF 6024 deep groove ball -bearing

Basic dynamic load rating	C	88.96	kN
Basic static load rating	C_0	80	kN
Fatigue load limit	P_u	2.75	kN
Calculation factor	k_r	0.025	
Calculation factor	f_0	15.9	
Number of balls	N	15	
Mass bearing		2.1	kg
Total weight of opposing vibration		57.83	kN

We know that the Bearing life equation with vibration

$$H = \left(\frac{C}{L+6.7753\times10^{-5}\times MVF}\right)^3 \times \left(\frac{16667}{RPM}\right)$$

Where

H= Ball Bearing life in hours /year

C= Manufacturer's bearing capacity in kN

L= In-service bearing load in kN

M=Weight in kN of mass opposing thevibration

V= Velocity of Vibrations in Inch/sec

F= Frequency of vibration = 30

Table3:How life decreases with increasing the vibration level of an SKF 6024 deep groove ball-bearing

S. No	Vibration In Inch / Sec or IPs	Bearing Load In Kilo Newton's	Bearing Life	Percentage of Life Compared To Life @ 0.2 Inch / Sec
1	0.0	4.45	8.444 years	230%
2	0.2	5.85	3.663 years	100%
3	0.4	7.26	1.900 years	51%
4	0.6	8.67	1.109 years	30%
5	1.0	11.49	4.729 months	12%
6	1.5	15.02	2.105 months	5.7%
7	2.0	18.54	1.115 months	3%
8	3.0	25.56	0.0424= 2.21 weeks	1.1%

Calculations for Unknown parameters

Exact bearing data may not always available. Use the following approximate calculations for unknown frequencies.

FTF = 0.4X RPM = 12Hz

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BPFO = 0.4 x N X RPM = 180 Hz
BPFI = 0.6 X N X RPM = 270 Hz
The ratio of inner to outer frequencies should be always 1.5

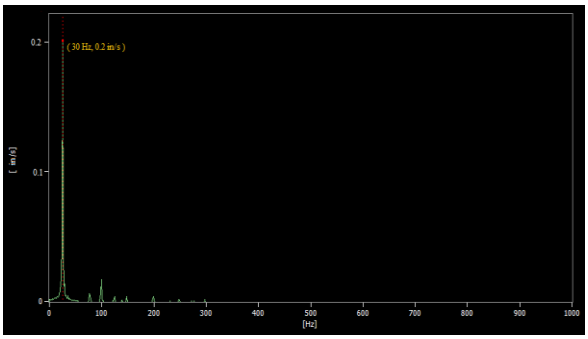

Figure6:The spectrum of bearing SKF 6025 with frequency 30Hz, 0.2 in/ sec amplitude

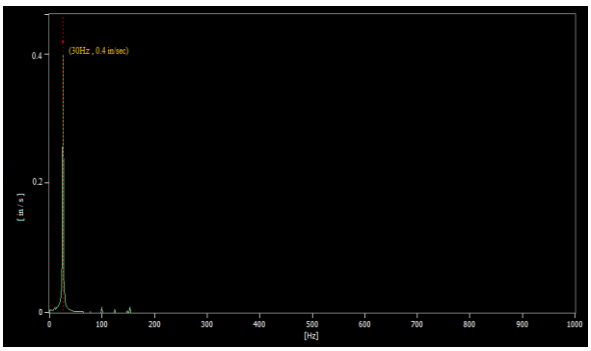

Figure7: The spectrum of bearing SKF 6025 with frequency 30Hz, 0.4 in/ sec amplitude

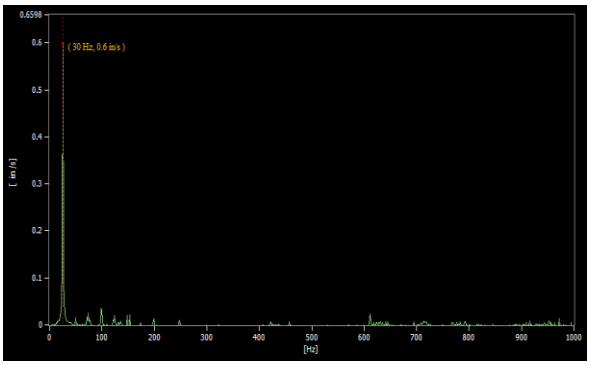

Figure 8:The spectrum of bearing SKF 6025 with frequency 30Hz, 0.6 in/ sec amplitude

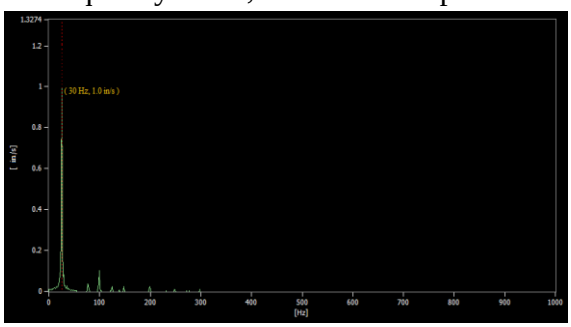

Figure 9: The spectrum of bearing SKF 6025 with frequency30Hz, 1 in/ sec amplitude

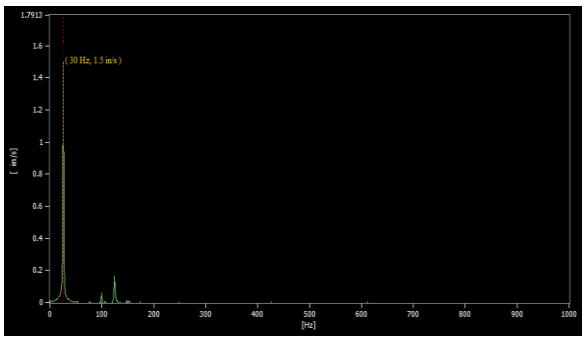

Figure 10:The spectrum of bearing SKF 6025 with frequency30Hz, 1.5 in/ sec amplitude

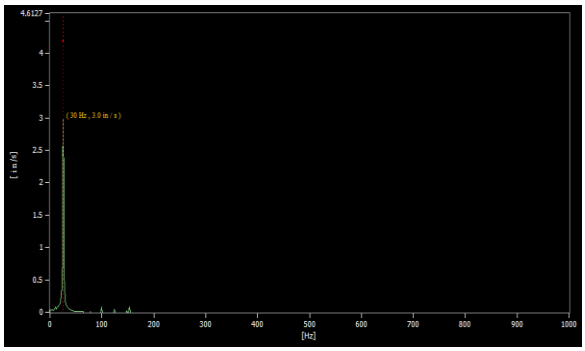

Figure11:The spectrum of bearing SKF 6025 with frequency 30Hz, 2 in/ sec amplitude

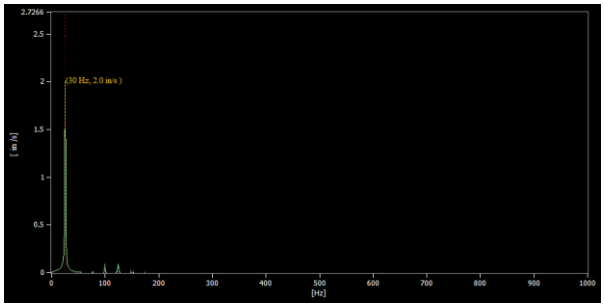

Figure12:The spectrum of bearing SKF 6025 with frequency 30Hz, 3 in/ sec amplitude

III. CONCLUSIONS

Breaking down the range is significant for exact flaw location and its underlying driver generally deceives to broken deficiency discovery. It resembles as opposed to unbalancing need to change the great condition bearing. At long last loses time, cash and creation misfortune. Subsequent to directing, the investigation discharged how vibration prompts the calamitous disappointment of the machine.

By running the bearing at a consistent speed with variable load, it found that expanding load; offers ascend to vibration level thus life of bearing life diminishes from 100% to 1.1%.Adding the load an

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outspread way by utilizing the pressure driven press, found the root of deficiency in the external race of a direction. Because of the loading factor, that also utilizing the speed sensor the crucial strain recurrence, ball pass recurrence of the internal race and ball turn frequencies are not uncovered appropriately, the uncovered one identified with ball pass recurrence of the external race. Bearing segments ordinarily bomb in the accompanying request; race imperfections, ball or roller deserts, confine deformity (except if the bearing was blemished when introduced). Since every one of the frequencies are diverse there is no possibility of reverberation at the activity condition.

The future extent of the work could be the investigation of bearing life by utilizing the present mark examination, wear flotsam and jetsam investigation. By utilizing, the accelerometers later on can uncover the frequencies of all FTF, BPFO, and BPFI. Can work out a similar issue with steady load with variable RPM's for study the conduct of bearing components.

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TEXTBOOK

1. Machine Condition Monitoring Principles and Practices by Amiya R. Mohanty.
2. Machine Design by RS Khurmi, JK Gupta

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