

## Study the effects of Solid and Liquid Contamination in Ball Bearing through Vibration Analysis

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**Abstract** - Ball bearings are widely used mechanical parts in Rotating Machinery, Automobiles and Aerospace etc, Bearings are Lubricated with Grease to Reduce Friction So that It Can Run Smoothly. Greases are often contaminated with Different Contaminants like Solid contaminants and Liquid Contaminants and these contaminations are prime Factors for Bearing Failure, Here we study the influence of both solid and liquid contamination in bearings. It is difficult to study the combined effect of solid and Liquid contamination but it can be done with the help of Vibration analysis Technique, The Data of clean bearing and the contaminated bearing were compared. Greases were contaminated with different size quartz particle with variable concentration and with different types of water form like salt water, Soap Water, Rain Municipal Water, Rain water of various concentration. The data were obtained by the Accelerometer and the vibrations were interpreted in the form of root mean square (RMS) values of amplitudes in term of acceleration and acceleration at particular defect frequencies, compared the data with healthy Bearing which revealed that due to contaminations there were sudden increment in Vibrations which reduced the life of Bearing

**Keywords:** Deep groove ball bearing, solid contaminant, liquid contaminant, greases, vibration

### 1. INTRODUCTION

Bearings are the main component of the rotating parts in the machines and their proper functioning depend upon smooth and quiet Running of bearings. Bearings are critical mechanical part in industrial applications any fault in the bearing can cause failure of machine thus the condition based maintenance are necessary for detecting the fault in order to increase the effectiveness of bearing used in the machine. Detection of fault in early stage can prevent failure thus save cost imposed due to it. There are various condition based monitoring Techniques for the detection and diagnosis of the bearing faults which predicts current and future condition of Bearing. These techniques are vibration and acoustic measurements [1], temperature measurements and wear debris analysis. Among the vibration based fault detection [2] most commonly used because vibration based condition monitoring is more reliable compared to other analysis Greases are contaminated due to environmental condition, mistake by human, direct metal to metal contact etc and

these Greases are used for lubrication in almost 90% of bearings which can cause damage to bearing [3]

The Life of Bearing is strongly influenced by the contaminations and these contaminations can be solid and liquid, Noise and vibration is produced by the solid contaminations, Analysis and study of vibration due to solid contamination is easily available [4,5,6] and few studies on vibration due to liquid contamination [7]

In This Article the objective is to study the effect of combined solid and liquid contaminations in Grease by Vibration signature analysis. Solid contaminants were taken in form of sand particles of different sizes and of different concentration. The liquid contaminants were water of different form like Salt Water, Soap Water, Municipal Water, Rain Water, There are not many literature available related to water contamination in Grease but some studies showed that only 1% of water in grease can have influenced the life of Bearing [ ]. Water also Initiated Rusting phenomenon, Texture and Adhesiveness can also be effected by the water in grease probably is an inferior lubricant Vibration Signals were analyzed in the form of RMS values and after analyzing the results some useful results were found

### 2. METHODOLOGY AND SAMPLE PREPARATION

**2.1 Bearing Selection**-The Bearing Selected for this experiment is Deep Groove Ball Bearing SKF 6303 whose outside diameter is 47 mm, bore diameter 17 mm and 7 number of balls. The Deep groove Ball Bearings are used because of High Load carrying Capacity and can run appropriately at high running speed. The size and Number of balls in bearing decides the load carrying capacity

**2.2 Grease** -The Grease used in this Experiment was Lithium complex soap based Grease and its amount were 5gms.

**2.3 Solid contaminants**-The solid contaminants were in form of Sand particles of 5 different sizes 75 micron, 90 micron, 100 micron, 300 micron and 425 micron with 3 concentrations, 0.75gm, 1gm, 1.25gm

**2.4 Liquid Contaminants**-Water of different types salt water soap water municipal water and rain water of concentration levels (10% and 15 % by weight of grease)

### 2.5 Mixing solid and liquid contaminants with Grease-

The Sand particles of different sizes and concentration and water of different types in variable % of grease weight were mixed with the grease in the speed mixer, The speed of the mixer was 1000 RPM for 8 minutes to made homogenous mixture, The mixed air was removed before any sample preparation by rotating mixer at 1200 for 2 minutes, from different variations of solid and liquid contaminations Total 120 samples can be prepared and from that 20 samples were used for the Experiment

**TABLE-1:** Samples constitute

Particle size(in microns)	Weight of sand(in grams)	Type of water	Percentage of water (gm per ml of grease)
75 (S1)	0.75 (P1)	Salt (W1)	10 (C1)
90 (S2)		Soap (W2)	
100 (S3)	1 (P2)	Rain (W3)	15 (C2)
300 (S4)		Mineral (W4)	
425 (S5)	1.25 (P3)		

### 3. EXPERIMENTAL SETUP

The setup which was used for the experiment was Machine Fault Simulator rotor dynamics simulator (MFS-RDS).Figure 2 shows the actual setup on which Experiment was carried out. The specifications of the setup are provided below. The setup was free from structure vibrations. The setup consists of a motor, shaft, Flexible coupling, bearing, tachometer, SKF FFT Analyzer, accelerometer etc.The software used for analyzing vibrations was Smart office.



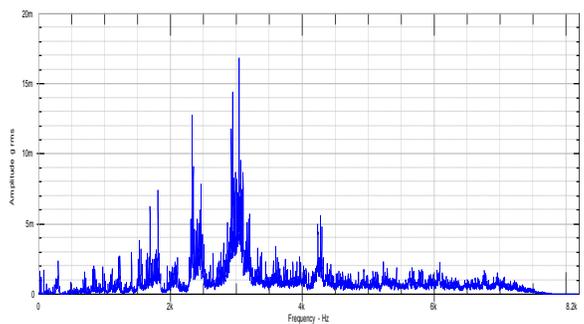
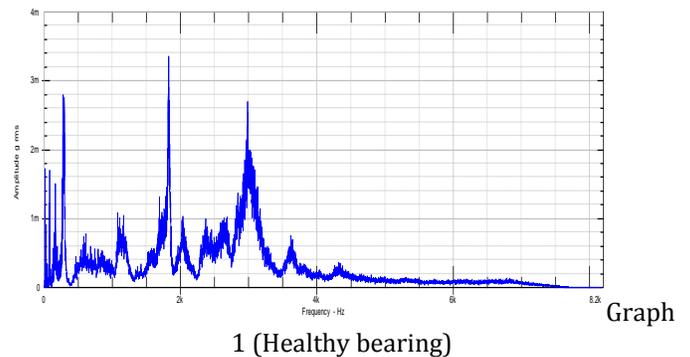
**Figure MFS-RDS Setup**

### 4. TEST AND DATA COLLECTION

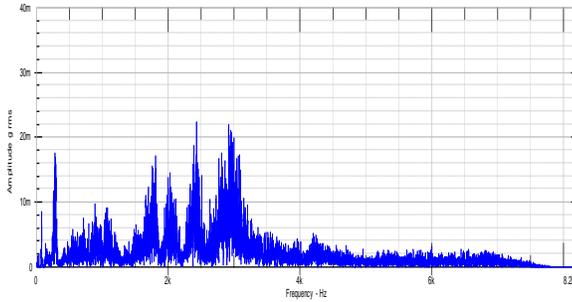
In this Experiment speed remained constant at 1200 RPM and the Tests were performed on 20 prepared samples. Test performed on 6303 Deep Groove Ball Bearing .Each Test followed the sequence of steps .First the bearing running in Healthy grease to stabilize the temperature of grease. In second step Test was continued with Healthy grease and vibration data were collected. In the next step contaminated bearing fixed in the shaft after which vibration data were collected for the contaminated bearings.

This Procedure was repeated for the remaining samples, The data of both healthy Bearing and Contaminated bearings were recorded and analyzed with respect to peak values, Root mean square values related to specific defect frequencies by the FFT analyzer, some of the results and comparisons are specified below

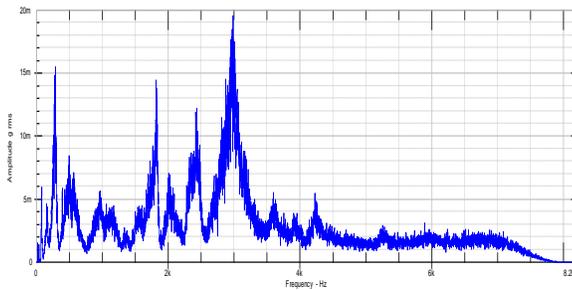
The following 3 Graphs between Amplitude (in mm) vs. frequency Shows the comparison between Healthy and contaminated Bearings



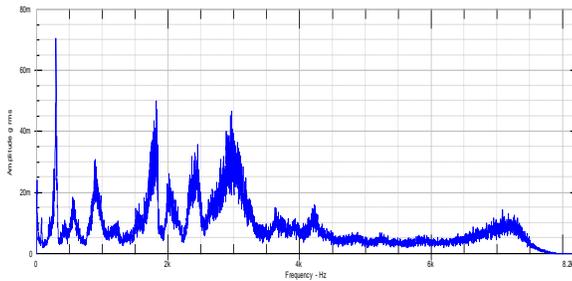
Graph 2 (Sample 2) (mineral water, 10%, 75microns, 0.75gm)



Graph 3 (sample 3) (salt water, 10%, 75microns, 0.75gm)



Graph 4(sample 4) (Rain water, 15%, 75microns, 1gm)



Graph 5 (Sample 5) (Rain water, 15%, 100micron, 1gm)

## 5. Results

To show the effect of water, comparison between sample 2 and sample 3 which are shown in graph 2 and graph 3 is done. Sample 1 (mineral water, 10%, 75microns, 0.75gm) and sample 3 (salt water, 10%, 75microns, 0.75gm) have same constituent except the water type. In the former one mineral water was used and in latter one salt water.

By analyzing the vibration signatures of graph 2 and graph 3, it can be inferred that peak value or amplitude remain nearly same in both the cases because Particle size and concentration remains unchanged. There is waviness in graph 3 compared to the graph 2, this is because in the sample 2 mineral water was used and in sample 3 salt water was used. From this comparison it is possible to say that salt water causes more damage than mineral water to bearings

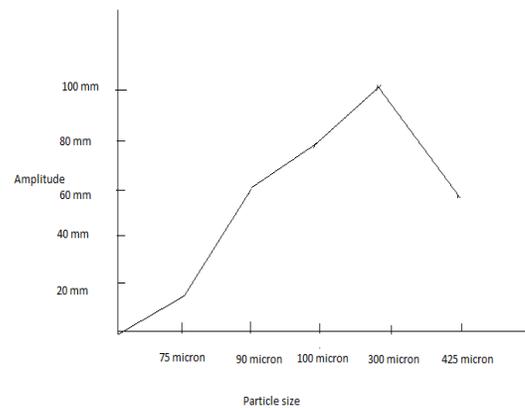
Sand particle effect shown in graph 4 and graph 5. The sample which are used for comparisons are sample 4 and sample 5.

Sample 4 (Rain water, 15%, 75microns, 1gm) and sample 5 (Rain water, 15%, 100micron, 1gm) have same constituent except the different particle size i.e. 75 micron and 100 microns respectively.

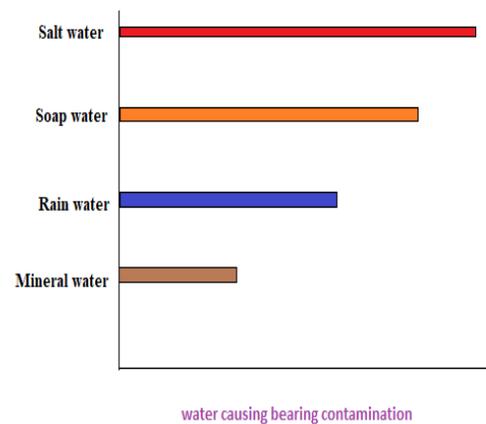
By analyzing the vibration trends, it is clearly visible that amplitude in graph 4 is around 20 mm and amplitude in graph 5 is around 70 mm which shows the particle size effect.

Waviness remains same as the same type of water was used in both the sample. It can be deduced that as particle size increase vibration trends also increases.

Vibration signature trends according to particle size shown in line graph below



Bearing most affected by the following water types shown in figure below



## 6. CONCLUSIONS

1. It is observed that with the increase in particle size vibration level first increases and then after certain size it decreases the most likely factor for vibration level decrement is particle settling effect.

2. Water of different types cause significant damage in the Bearing, because of water waviness produced in the graphs, multiple time peak amplitude came which causes the wear in the Bearing i.e. corrosion wear, abrasive wear and it is visible in the Bearings after the test.

3. Particle concentrations have similar effect as particle size when both combined then up to certain limit vibration level increases.

4. The waviness in the graphs and the corrosion wear are more significant in Bearing with salt water and least with mineral water. Soap water comes before the rain water.

## 7. FUTURE SCOPE

1. Finite Element Analysis of this Experiment

2. Study the combined Effect of solid and liquid contamination by Acoustic emission method, Stator current Method, Shock pulse method

3. Test can be performed on other Bearings like Hydrodynamic Bearings etc

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