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Vibration Analysis of Ball Bearing with Grease Contaminated by Sand and Water both

Akhilesh Soni[1], Surendra Singh Dewada[2], Ambuj Pateriya[3]

1Assistant Professor, Dept. Of Mechanical Engineering, MANIT Bhopal, Madhya Pradesh, INDIA
2M.Tech. Scholar, Dept. Of Mechanical Engineering, MANIT Bhopal, Madhya Pradesh, INDIA
3M.Tech. Scholar, Dept. Of Mechanical Engineering, MANIT Bhopal, Madhya Pradesh, INDIA

Abstract - *Rolling contact bearings are commonly used in many fields. Among Rolling contact bearings ball bearings are extensively used in rotating machineries. In ball bearings Semi solid lubricant grease is used to reduce the friction in between the races and balls. Grease is being contaminated by solid and liquid contaminants in actual working conditions. This is the major reason for the failure of the bearing. Hence in this analysis both the contaminants have been used. In liquids Salty water, Soap Water, Rain Water and Mineral water is being taken and Sand as a solid contaminant. There are many methods to analyse the alterations in the bearing performance due to contaminated grease. Vibrations measurement is being chosen because it shows best trends. Samples of different contaminations of both water and solid has been prepared by the use of speed mixer and filled into the 6303 SKF Ball bearings. They are tested on the MFS RDS set up at 1200 rpm. Results obtained were in the form of amplitude in RMS values v/s defect frequency plots. These plots for different samples are obtained and compared mutually and with that of healthy bearing*.

Keywords: 6303 2RS ball bearing, contamination, grease, accelerometer.

1. INTRODUCTION

Lubrication in the bearings is very essential for suitable working and long life. In ball bearings very, high hydrodynamic pressure is being developed in between the races and the balls. This pressure can generate faults in the surface of bearing unless the monitoring of bearing is not done properly. Defects in bearings may rise during practice or at the time of the manufacturing process.

Therefore, detection of these defects is essential for condition monitoring and quality inspection of bearings. Condition monitoring also permits the repair. There are various methods for the detection of these defects. Broadly they are of following types: Vibration Measurement, acoustic measurement, temperature measurement and wear debris analysis Many techniques are used to measure the vibration and acoustic impulses from defective bearings; i.e., vibration measurement and defect frequency response, shock pulse method, sound pressure and sound intensity techniques and the acoustic emission method. From these Vibrations measurement is generally used. [1]

Solid and liquid contaminations are the main cause of these generated vibrations. According to M.M. Maru, R.S. Castillo, the vibrations level generated due to solid contamination will be dependent on the size of the solid particles, concentration of solid particles. [3], so different configurations of the water and solid particles are tested to analyse the proper effect of contamination.

1.1 Contaminants

Contaminant is another term for pollution. The undesirable substances which are mixed with grease are called contaminants. [2] When Bearings runs as a part of a machine assembly it will be contaminated by these substances. Contaminants can be solid and liquid both. Solids can be dust, mud, sand and many others. Liquid contaminants are water, oil, chemicals etc.

1.2 Factors which influences the performance of bearing

According to SKF standards many factors are responsible for degraded performance of bearings. Sequence of their effect is given in the above table. Inadequate lubrication and contamination is mostly the cause of failure of bearing

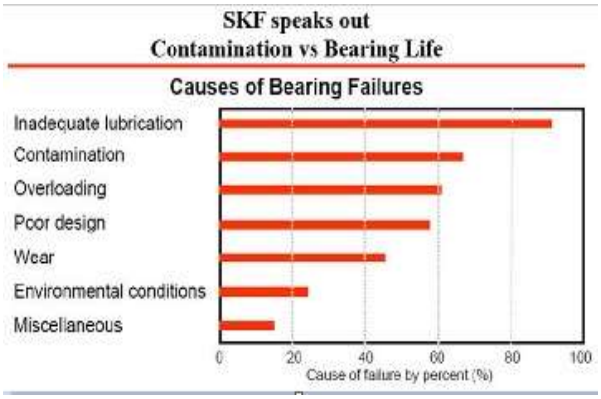


Fig. - 1 Causes of bearing failure

2. MATERIAL AND INSTRUMENTS REQUIREMENTS

There are distinct contamination of grease is used. There can be infinite number of combinations can be formed by using different water, different solid
particles etc. but here 4 kinds of water is taken. And in solid only sand particles are taken. Hence, we can compute the list of materials as below
Salt water, Soap Water, Mineral Water, Rain water, sand particles, weighing machine, different sieves to fix the particle size, 6303 RS2 bearings, LiX (Li based Grease), Kerosene, Speed Mixer and smart office software is used.
Bearing 6303 is have inner race diameter of 17mm and outer race diameter of 47 mm. It is having 7 balls in the races. Bearing material is alloy steel.

3. EXPERIMENTAL SETUP

The setup which is being utilised is MFS RDS, for vibration fault detection.

3.1 Accelerometer

Accelerometer is a device which is used to measure the dynamic acceleration in the form of voltage. Accelerometers are useful sensors used for both high or low frequency vibration. [10]

Fig. - 2 Accelerometer

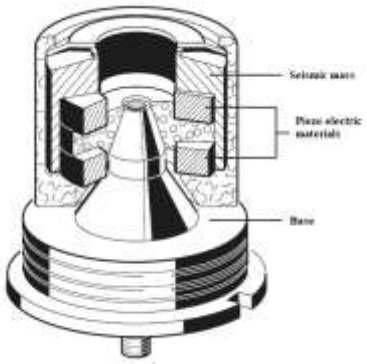


Fig. -3 Working of accelerometer

DYTRAN accelerometer is used to measure the vibrations. Sensitivity of this accelerometer is 47.88 mV/g. It is a piezoelectric kind of accelerometer. Piezoelectric materials creates a charge or certain voltage over their surface when any force is applied on the surface of the material. When this force is removed from the surface of material this charge will be disappeared. Piezoelectric is a concept of transducer. In accelerometer piezoelectric materials are in triangular form and put in between the frame and the seismic mass. So, the signals generated will be relative to both.

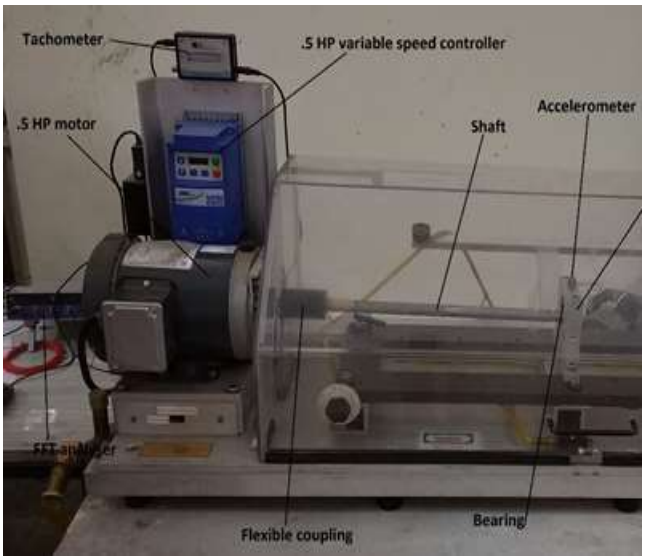


Fig. - 3 Machinery fault simulator rotor dynamics simulator

3.2 FFT Analyser

A Fast Fourier Transform(FFT) decomposes a sequence of values into components of different frequencies. Basically,time domain vibration signal is proceesed into frequency domain by applying a fourier transform, usually in the form of a fast fourier transform algorithm.

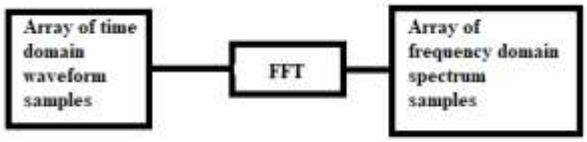


Fig.- 4 Basics of FFT analyser

Fig.- 5 FFT analyser

4. SAMPLE PREPARATION

It is needed to prepare different samples of grease to test the bearing. Grease has to be mix with the water and the sand. 5 gm of LiX complex based grease is taken for each sample. This grease is rotated in the speed mixer with the proportionate amount of water and sand particles. Speed mixer is rotated at a speed of 1000 rpm for 8 minutes. After that speed mixer is rotated at 1200 rpm for 2 minutes to remove the air bubbles that are generated due to mixing. This process is repeated until the prepared sample is homogeneous and uniform.

Here is the table below for the total samples taken

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)		
300 (S4)		Rain (W3)	15 (C2)
425 (S5)	1.25 (P3)	Mineral (W4)	

Fig. - 5 Configurations of contaminants

five sizes of sand particle size i.e. 75,90,100,300,425 (in microns), 3 configurations of concentration of sand i.e. .75gm, 1gm, 1.25gm.

4 types of water i.e. Salt water, Soap Water, Rain water, Mineral water, 2 concentrations of water i.e. 10% 20% Samples is being made by the combinations of these configurations. Like S1P2W3C1. There can be 120 samples by taking this. Out of this 20 samples are chosen because complete process of testing a bearing is time consuming process.

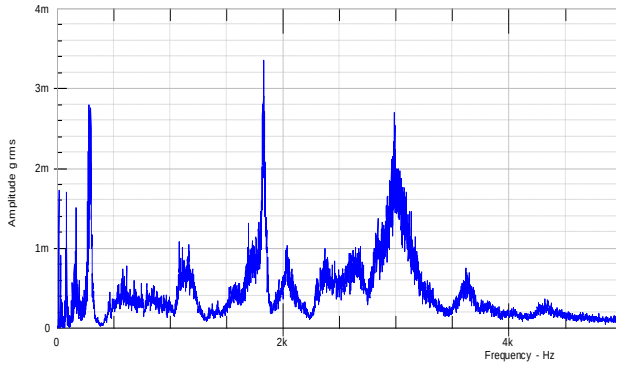
5. STEPS OF METHODOLOGY

Firstly, healthy bearing is tested on MFS RDS setup. For contaminated bearing test Grease of another bearing is removed with the help of kerosene. After that 20 grease samples are prepared. Grease is refilled into bearings and these samples are kept for 5 days. This is done to create significant effect of water.so that it can be compared with the results of healthy bearing. Now these contaminated bearings are tested on the setup. Speed of rotation of shaft is taken as 1200 rpm. This is fix for all the bearings. Results obtained were converted into frequency form by FFT analyser.

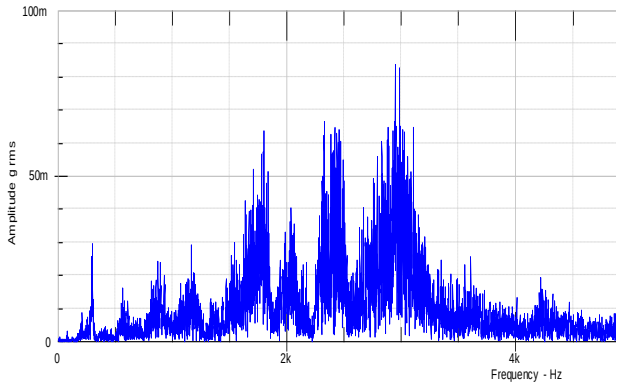
6. RESULTS AND DISCUSSION

Amplitude given is in the form of RMS values. Unit of amplitude is milli meters. Total 20 samples were tested and 1 healthy bearing is tested.

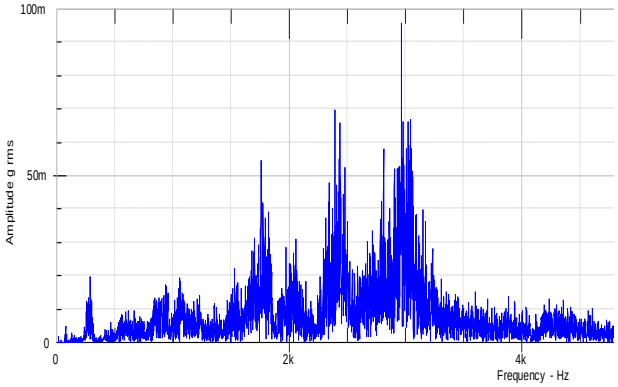
Results are obtained as a graphs of amplitude v/s defect frequency. From these graphs only three graphs are shown below i.e. graph1, graph 2, graph 3. The graph 1 is plotted for the bearing in which healthy grease is filled. Graph 2 and Graph 3 are plotted for bearings which are contaminated.



Graph-1. Healthy bearing (LiX Grease)



Graph - 2. Contaminated bearing with sample S4P2W2C1



Graph - 3. Contaminated bearing with sample S4P3W1C1

It can easily be seen from all the three graphs that maximum amplitude is very high in case of contaminated bearing as compared to the healthy bearing. By comparing the graph 2 and Graph 3, The samples used are S4P2W2C1 and S4P3W1C1. The difference in the samples are only of concentration of sand and type of water. In graph 2, 1gm of sand with salt water is present.

In Graph 3, 1.25gm of sand with soap water is present. By comparing these two graphs and other samples also it can be said that due to water contamination vibrations increase. In Graph 2 peaks of amplitudes are uniform for most of the time and in Graph 3 peaks are obtained. It can be concluded that this is due to the water effect. Graph 2 more haziness is there due to salt water and in case of soap water is it less. Concentration and size of sand particles in the maximum amplitude of vibrations as in graph 3 maximum amplitude is more than graph 2. But after some time, vibrations level decreases slightly this happens after the Particles are stabilized or they have taken the space on the surface due to the vibrations.

7. CONCLUSIONS

The mains purpose of the study is drawin the conclusions. Following are the conclusions of this research work:

- As the particle size of sand particle increases the level of vibrations increases up to a certain limit. But after a limit the vibrations level starts to decrease. The reason behind this may be the particle settling effect.

- Particle size deals with the maximum amplitude of vibration. i.e. as the particle size increases the maximum amplitude of vibrations will increase. It is not concerned with that at all defect frequencies higher peaks will obtained.

-Type of water also significantly effects the performance of bearing. By changing the water haziness will increase or decrease. Salt water produces maximum haziness among the four. i.e. salt water, mineral water, soap water, rain water. The sequence of effects of different water is:

1. Salt water
2. Soap water
3. Rain water
4. Mineral water

- Concentration of water has similar kind of concern as type of water. If the concentration of water in grease is more then it will create more haziness in the graph. But if the concentration of water is less in the grease then the level of haziness will be less. Hence the wear will be more in case of more concentration of water.

8. FUTURE SCOPE

This study can be a base for further researches like:

-These results can also be obtained and verified by FEM (Finite Element Method).

-Analysis can also be performed on the basis of temperature. Thermal stresses generated may be calculated with their corresponding locations.
-Wear analysis, acoustic analysis and debris analysis can also be performed.
-Tests can be performed on other hydrodynamic bearings.
-These results are obtained in frequency domain format. They can be obtained in the time domain format with both solid and liquid.

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