ISSN 2395-1621

Analysis of effect of solid contaminants in lubrication on vibration response of ball bearing.

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ABSTRACT

Aim of this paper is to analyze the effect of solid contaminant in lubrication on vibration response of ball bearing. Rolling element bearings are common in any rotating machinery. They are subject to failure under continuous running. Therefore they have received a great deal of attention in the field of condition monitoring. In rolling element bearings, contamination of lubricant by solid particles is one of the several reasons for an early bearing failure. This project investigates the effect of contamination of lubricant by solid particles on the behavior of rolling bearings. in order to determine the trends in the amounts of vibration affected by contamination in the Grease and by the bearing wear itself .Solid contaminate at three concentration levels and different particle sizes is used to contaminate the lubricant. An experimental test is to be performed on the ball bearings lubricated with grease, and the trends in the amount of vibration affected by the contamination of the grease determined. The sawdust is used as contaminant. The contaminant concentration as well as the particle size is varied. Vibration signatures is analyzed in terms of root mean square (RMS) values and also in terms of defect frequencies .From the results, The effects of contaminant and the bearing vibration is studied for both good and defective bearings. Then find significant variation in the RMS velocity values on varying the contaminant concentration and particle size. A way of monitoring machinery performance during operation is through mechanical vibration measurement. In rolling bearings, a sudden increase in vibration can be indicative of failure occurrence. In other techniques such as grease analyses and temperature monitoring can also provide warning of faults. But here, vibration monitoring is more versatile since it can reveal a wider range of faults.

Keywords— frequency spectrum, good bearing, healthy grease , particle size , rolling element bearing ,solid contaminate.

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I. INTRODUCTION

Bearing are important component in any rotating machine. The work is being carried out on the conditioning monitoring of machine and bearing, if bearing fails then machine will fail after certain period. In bearing there are lubrication, in lubrication if contaminant of different size and concentration mix then bearing fail. So that effect of contaminant in lubrication on vibration response of ball bearing is checked. The aim of vibration measurement method for rolling ball bearing have considered for detection of bearing faults in earliest stage, there are different method of study like acoustic emission method, shock pulse[2] method for study effect of contaminant in lubrication. But vibration analysis method is less costly and accurate method. Hence FFT analyzer is used for vibration analysis in the form of RMS values. The effect of contaminant in lubrication on the good and defective bearing is checked. Very high contact pressures elastically deform the surfaces, giving origin to small elliptical contact areas. The cyclic formation of the elastically deformed contacts eventually leads to surface fatigue. Palling is known as the typical failure mechanism happening in rolling bearings lubricated by grease. The elastic deformation is subject to the existence of material defects near the subsurface region, as well as to the presence of solid particles in the contact interface. The surface initiated damage due to grease contamination has become one of the main causes of bearing failure. Generally bearings do not reach their calculated life time and they fail during service. Fifty percent bearings fail due to the lubrication problem.

II. LITERATURE REVIEW

Sir JuhaMiettinen gives the classification and distribution of the reasons for which rolling element bearings did not reach their calculated lifetime. Fifty percent consists of lubrication problems, poor lubrication and contamination. The acoustic emission signal measured from a grease lubricated rolling bearing indicates risks in the lubrication of the bearing. By reducing the level of the acoustic emission the risk of premature failure of the bearing can be reduced. He has used the AE method for his work, he also has given very great explanation of Vibration analysis method, as it is the most commonly used technique for condition monitoring.

Zhenyu Yang and Uffe C. Merrild he stated that, bearing faults could happen with the raceways, ball or rolling-element and the cage as well, such as a scratch on the surface of the raceway. The bearing faults occurs due to improper installations of the bearing onto the shaft or into the housing, misalignment of the bearing, contamination, corrosion, improper lubrication, simply due to wear-out. Bearing faults can be classified into two general categories: single-point defects and generalized roughness. A single-point defect is defined as a single, localized defect on a bearing component surface. Generalized roughness corresponds to the situation where the condition of a bearing surface has degraded considerably over a large area, and become rough, irregular, or deformed.

Extensive research work can be found focusing on the FDD (Fault Detection and Diagnosis) of the single-point defect, due to the fact that a single defect will produce one of the four characteristic fault frequencies depending on which bearing component contains the fault. The vibration measurement of the motor shaft plus advanced signal processing techniques used to measure or detect these characteristics. The Fast Fourier Transform (FFT) is used to detect these charactristics,By comparing the spectra generated based on a nominal operation and a fault-suspected operation around these characteristic frequencies, if some obvious difference can be observed, the corresponding fault scenario will be claimed.

Mr. M.M.Maru explains in his work, the effect of contaminant concentration on vibration is distinct from that of the particle size. The vibration level increased with concentration level, tending to stabilize in a limit. On the other hand, as the particle size increased, the vibration level first increased and then decreased. Particle settling effect was the probable factor for vibration level decrease. Vibration levels increased along the test in contaminated oil even with only 16 min of test. Such an increase in vibration is related to an effect produced by the wear of bearing elements. The bearing parts were severely damaged by a peeling-like mechanism, distributed along all the surface. This was indicative of severe wear regime, although measurements of internal radial clearance of the bearings have indicated absence of dimensional wear. The vibration amount due to the bearing wear was dependent on the contamination feature. An apparent correlation between the trends of the worn bearing vibration and those of its overall surface damage was observed. The vibration due to the presence of particles was proportional to the vibration of the worn bearing as particle concentration increases. On the other hand, when the contaminant particle size increased, the dynamical action of the particles passing through the contact interface.

III.CONTAMINANT

The different materials has the different effect on the bearing, hence the contaminant material also can be varied to study the effect. The materials can be varied according to their properties like hardness, ductility. Also contaminant can be varied in their sizes and concentration. The variation of size and concentration changes the effect on vibration of bearing. This contaminant produce effect in lubrication with increase in contaminant, lubrication (grease) film thickness decreases. There are different contaminant like metal burr, dolomite powder, iron-ore, sawdust. We consider here sawdust as a contaminant in lubrication for vibration response of ball bearing.

IV.BEARING SELECTION

6206-2RS deep groove ball bearing is used for this project. Geometry of bearing is shown below.

Bearing outside diameter, D= 62mm
Bearing bore diameter, d =30mm
Bearing width, B= 16mm
Ball diameter, BD= 9.6mm
Cage diameter, Dc=46mm
Contact angle, β= 0
Number of balls, n =9

V. PREPRATION OF SAMPLE

Grease is used as a lubricant. The grease weight is selected by considering a standard empirical relation.

The relation is given as, G=0.005DB

Where G is grease quantity (g), D is the bearing outside diameter (mm), and B bearing width (mm) [8]. Bye the calculation made according to above formula, the quantity of grease estimated is 5gm. The preparation of sample based on varying weight percentage of contaminant according to the weight of grease and size of contaminant. These sample sizes of 53, 75, 105 (in micron) are then added in the grease in different concentration levels as 5%, 15% and 25% of the grease weight.

Table below shows the bearing sample number and specification. First three reading shows bearing running in healthy condition without contaminant and remaining reading indicate the bearing running with different size of contaminant and concentration of contaminant.

TABLE I
Bearing sample numbers with specifications

Sr.No.	**Contaminate Material**	**Contaminant Size (micron)**	**Contaminant Concentration(%)**	**Bearing Sample No.**
1	Healthy	Nil	Nil	Healthy
2	Healthy	Nil	Nil	Healthy
3	Healthy	Nil	Nil	Healthy
4	Sawdust	53	5	S1C1
5	Sawdust	53	15	S1C2
6	Sawdust	53	25	S1C3
7	Sawdust	75	5	S2C1
8	Sawdust	75	15	S2C2
9	Sawdust	75	25	S2C3
10	Sawdust	105	5	S3C1
11	Sawdust	105	15	S3C2
12	Sawdust	105	25	S3C3

VI. EXPERIMENTATION

The experimental set up for project is shown in below figure.

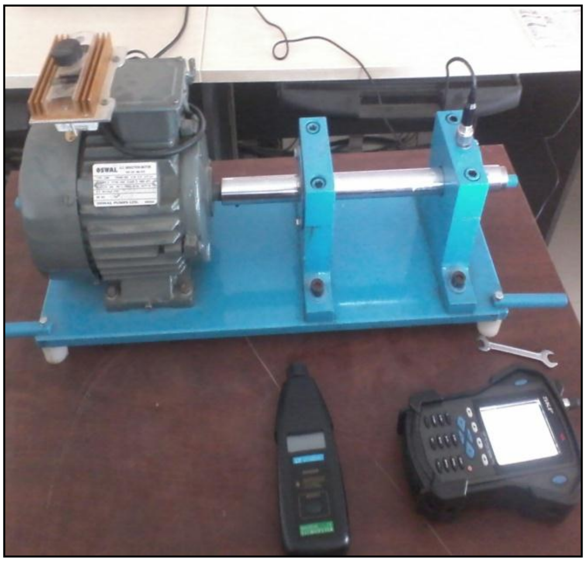

Fig no.1 Actual experimental setup

Experimental test is performed in three steps. In the first step running the bearing running in healthy condition to stabilize the grease temperature. The test is continued in the second step in healthy grease to collect the vibration data at constant speed. In the last step, the contaminated grease is applied to the bearing. With contaminated grease Vibration signals are acquired from the bearing housing at constant speeds. This procedure is repeated for all concentration levels. Data is recorded and analyzed with respect to peak values and the root mean square (RMS) values, related to specific defect frequencies.

TABLE III
Frequency Equations Required

Characteristic frequency	**Symbol**	**Equations**
Shaft Rotational Frequency	Fs	N/60
Inner race defect frequency	Fid	n/2*fr[1+(bd/pd)*cosβ]
Outer race defect frequency	Fod	n/2*fr[1-(bd/pd)*cosβ]
Ball defect frequency	Fbd	Pd/2bd*Fr[1-(bd/pd)2*(cosβ)2

Where,
N:-rotational speed of shaft in RPM
n:-No. of balls
Fr:-Shaft Rotation Frequency
bd:-Ball Diameter
β -Contact angle

TABLE IIIII
Fault frequencies at 1495 speed

Sr.No.	N (RPM)	Fs (Hz)	Fid (Hz)	Fod (Hz)	Fbd (Hz)
1	1495	24.92	139.3	89.7	114.16

Fault frequencies are calculated at constant speeds are given in above table. These values are further used for analysis. The acceleration values are recorded at these frequency values.

In the bearing sudden rise in vibration can shows failure occurrence. For certain bearing element rise in vibration at this element rotational defect frequency may occur, the defect frequency calculated from geometry of bearing and its rotational speed. Defect frequency lies in low frequency range for normal speed, failure of machine may result from excessive forces which break the lubrication and bearing to be failed at high frequency.

VII. RESULTS AND DISCUSSIONS

The data is tried to analyze in terms of peak-values and RMS values, related to specific defect frequencies. Following are some examples of vibration signatures obtained from test by using FFT analyzer when sawdust is used as a contaminant. The figures show the Acceleration Vs. Frequency graphs for the bearing.

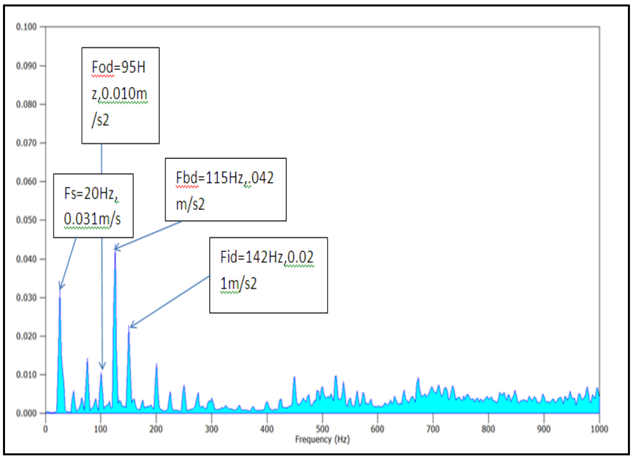

Fig no.2 Acceleration-Frequency plot for bearing sample S1C1running at 1495 rpm.

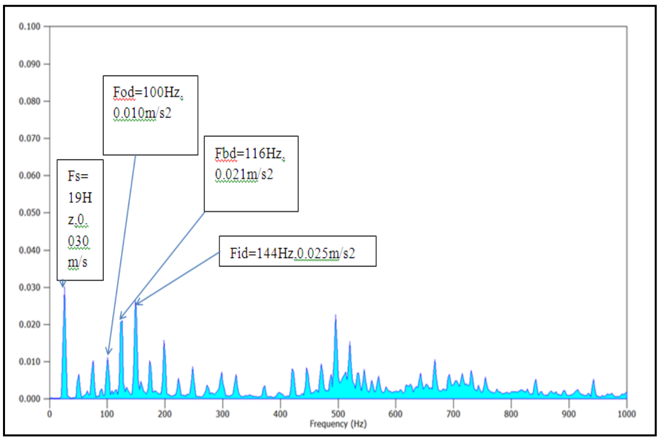

Fig no.3Acceleration-Frequency plot for bearing sample S1C2 running at 1495 rpm.

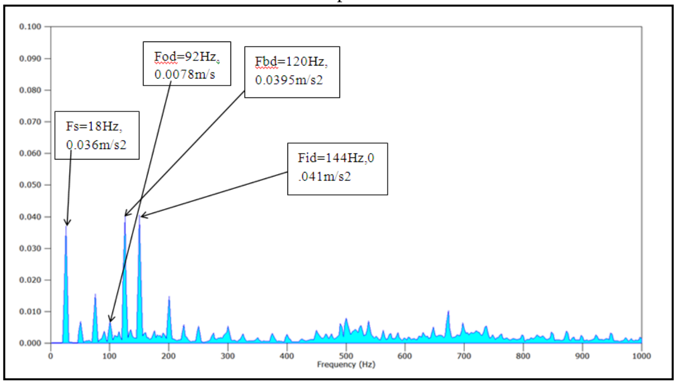

Fig no.4Acceleration-Frequency plot for bearing sample S1C3 running at 1495 rpm.

The fig no 2,3,4 indicate the signatures obtained when the contaminant material used is sawdust, size of particle taken as 53micron, 75micron, 106microns, With concentration levels changed as 5%, 15%, and 25% respectively. It shows that, as the concentration level is increased, then acceleration value at some of the defect frequencies goes on increasing and some of defect frequencies decreasing, i.e. the acceleration value at outer race defect frequency is goes on decreasing and the acceleration values for inner race defect frequencies and ball defect frequencies are goes on increasing. This is happening because at smaller particle size at higher concentration levels the particles may not come in vicinity of outer race. Similar way we can see the graphs for remaining concentration and size of sawdust particle.

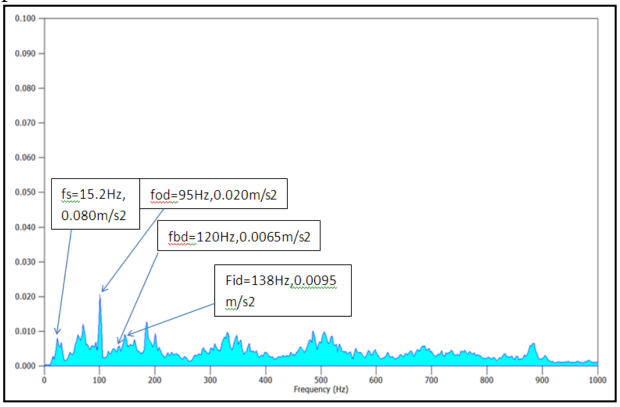

Fig no 5.Acceleration-Frequency plot for Healthy bearing sample running 1495rpm

It shows signatures obtained for healthy bearing with contaminant free grease. It indicates all the frequencies are at minimum level this is happen because there is no medium present in grease which produces the vibrations in the same bearings.

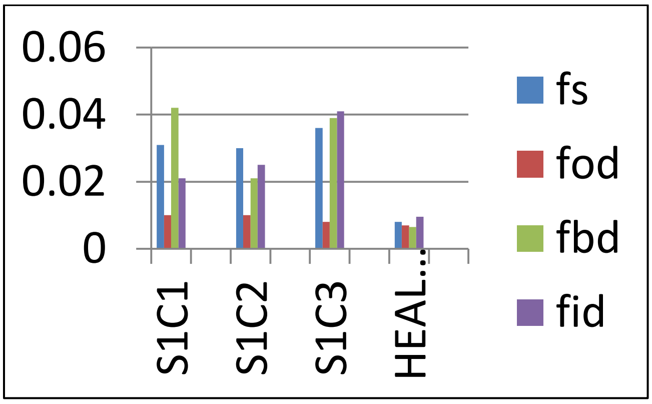

Fig no.6Acceleration Vs. Contaminant Concentration for bearing sample S1C1,S1C2,S1C3 at 1495 RPM

Above fig Shows the effect of concentration variation along with particle size on RMS acceleration value at speed 1495 RPM for the sample S1C1, S2C2, S3C3.
Similar way we are shows the result for the sample S2C1, S2C2, S2C3, S3C1, S3C2, S3C3.

VIII.CONCLUSION

In the present work, we study the effect of contaminant in grease on vibration response of ball bearing. For healthy bearing with contaminant free grease, it indicates all the frequencies are at minimum level because of no contaminant in the grease. Sawdust is considered as solid contaminant. As the contaminant particle size increased, the corresponding acceleration values also go on increasing up to certain limit, then it stars getting decreased. This may happen because, the contaminants occupy the corners present in the bearing by virtue of their weight, hence they doesn't come in contact with rotating elements. This decrease in vibration amplitude is due to more internal resistance of the bearing, due to not only larger particle but also concentration.

With smaller particle size and varying concentration level, we get the desired results. This may be happening because, the particles may not come in direct contact with rotating elements.

For defective bearing conditions, significant peaks at the bearing fault frequencies are observed.

If we consider larger sized contamination particles increase surface waviness considerably. As a result, the vibration level increased considerably at larger particle sizes. We study the vibration response of ball bearing in lubrication without contaminant and with contaminant of different size and concentration. And from that condition of bearing that are usable or not usable are checked.

ACKNOWLEDGEMENT

I would like to express my deep sense of gratitude to my supervisor Prof. Nehe S. S. And Prof.B.Aantarama for his inspiring & valuable suggestions. I am deeply indebted to him for giving me a chance to study this subject & providing constant guidance throughout this work.

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