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Study on the Vibration Response of Ball Bearings Due to Solid Contaminants in Lubrication.

Vivek S. Godase[1], Prof. Dr. A. D. Desai[2], Prof. Dr. S. D. Shinde[3], Mr. P. G. Sarasambi[4], Mr. S. P. Godase[5].

P.G. Student, Department of Mechanical Engineering[1]

Professor, Department of Mechanical Engineering[2]

Assistant Professor, Department of Mechanical Engineering[3,4,5]

Shree Ramchandra College of Engineering, Lonikand, Pune, Maharashtra, India

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 dynamic behavior of rolling bearings. 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 analysed in terms of root mean square (RMS) values. 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.*

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

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 methode,shock pulse[2] method for study effect of contaminant in lubrication. but vibration analysis methode are less costly and accurate methode. 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.

II. 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.

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III. 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

IV. 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 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

Table 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.

V. EXPERIMENTATION

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

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.

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Fig no.1 Actual experimental setup

TABLE II: 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 III: 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 occurs, 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.

VI. 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.

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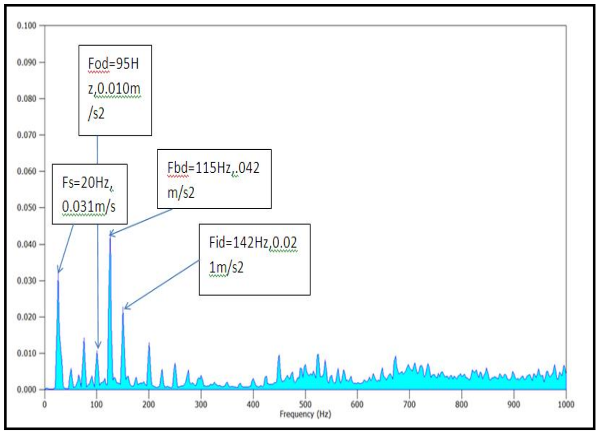

Fig no.2 Acceleration-Frequency plot for bearing sample S1C1running at 1495 rpm.

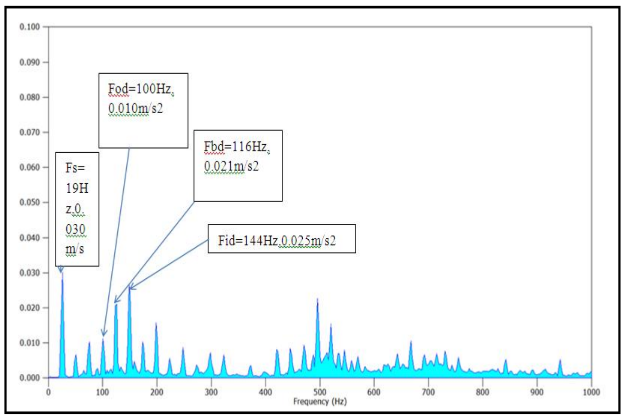

Fig no.3Acceleration-Frequency plot for bearing sample S1C2 running at 1495 rpm.

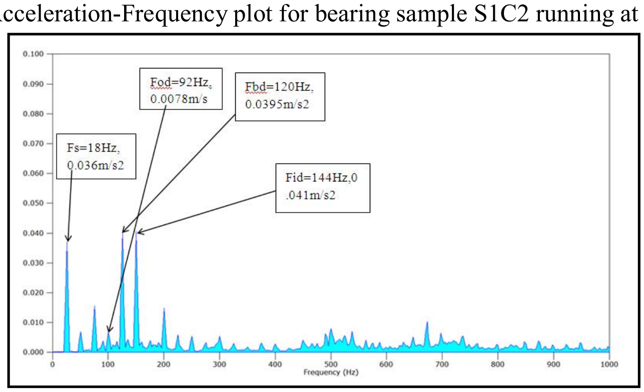

Fig no.4Acceleration-Frequency plot for bearing sample S1C3 running at 1495 rpm.

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 partical.

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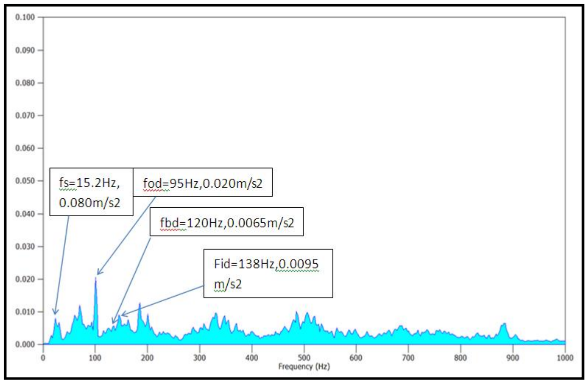

Fig no 5.Acceleration-Frequency plot for Healthy bearing sample running 1495rpm

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 a grease which produce the vibrations in the same bearings.

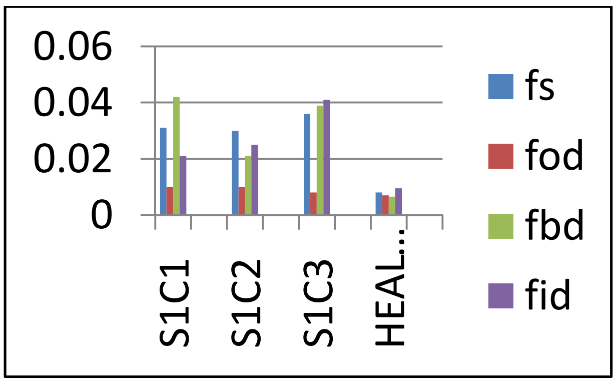

Fig no.6Acceleration Vs. Contaminant Concentration for bearing sample S1C1,S1C2,S1C3 at 1495 RPM

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.

VII. 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. With contaminant concentration level increases, The vibration level increased tending to stabilize in a limit. On the other hand, as the particle size increased, the vibration level first increased and then decreased. Size of particle taken as 53µm, with concentration levels changed as 5%, 15%, and 25% respectively. With the help of pointers the Acceleration values are shown at particular defect frequencies. The conclusion is as the concentration level is increased, there is an increase in acceleration value at all the defect frequencies and also there is considerable increase in RMS acceleration value.

With 75 µm size and the concentration level increased as 5%, 15%, 25% respectively. It shows that, as the concentration level is increased, the acceleration value at all defect frequencies goes on decreasing. This is happening because at higher particle size at higher concentration levels the particles may not come in vicinity of rotating element.

With 106µm size and concentration level varied as, 5%, 15%, and 25% respectively. At this particle size as concentration level increased the acceleration value at inner-race defect frequency decreases and at outer-race defect frequency increases. This is happening because of more weight the particles tend to move the outer side of bearing. If we consider larger sized contamination particles increase surface waviness considerably. As a result, the vibration level increased considerably at larger particle sizes. In this way we studied the effect of solid contaminant in lubrication on vibration response of ball bearing.

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REFERENCES

[1]. Zhenyu Yang, Uffe C. Merrild, “A Study of Rolling-Element sBearing Fault Diagnosis Using Motor’s Vibration and Current Signatures”, 7th IFAC Symposium on Fault Detection, Supervision and Safety of Technical Processes, Barcelona, Spain, June 30 - July 3, 2009.

[2]. JuhaMiettinen , Peter Andersson, “Acoustic emission of rolling bearings lubricated with contaminated grease.”, Tribology International 33 (2000) 777– 787.

[3]. N. Tandon, G.S. Yadava, K.M. Ramakrishna, “A comparison of some condition monitoring techniques for the detection of defect in induction motor ball bearings”, Mechanical Systems and Signal Processing 21 (2007) 244–256.

[4]. Tandon,, K.M. Ramakrishna, G.S. Yadava, “Condition monitoring of electric motor ball bearings for the detection of grease contaminants”, Tribology International 40 (2007) 29–36.

[5]. M. Kotb Ali, M. F. H. Youssef, “A Study on Fault Diagnosis by Vibration Analysis at Different Loading and Speed Conditions”, 13th International Conference on Aerospace Sciences & Aviation Technology, Asat- 13, May 26 – 28, 2009.

[6]. PavleBoˇskoski , JankoPetrovcˇic, “Detection of lubrication starved bearings in electrical motors by means of vibration analysis”, Tribology International 43 (2010) 1683–1692.

[7]. M.M. Maru, R.S. Castillo, “Study of solid contamination in ball bearings through vibration and wear analyses”, Tribology International 40 (2007) 433–440.

[8]. V Hariharan, P S SSrinivasan, “Condition monitoring studies on ball bearings considering solid contaminants in the lubricant”, Journal of Mechanical Engineering Science 2010 224: 1727, DOI: 10.1243/09544062JMES1885.

[9]. Bhandari V.B., “Machine Design”, Tata McGraw-Hill, 3rd edition, 2010.

[10]. AttelManjunath,D.V.Girish “Defect detection in deep groove polymer ball bearing using vibration analysis”, International Journal of Recent Advance in Mechanical Engineering (IJMECH) Vol.2, No.3, August 2013.

[11]. MangeshDhavlikar,Dr.S.B.Wadkar “Condition Monitoring of ball bearing using statistical analysis”, International Journal of Scientific Advance Engineering and TechnologyVol.3, Issue No.2, pp:186-192.

[12]. AbhayUtpat, R.B. Ingle, M.R. Nandgaonkar, “Study of vibration response characteristics of deep groove Ball Bearings with localized defect on its races”, Journal of Mechanical Engineering,(ISSN-0039-2472),), 62, 5-6 ,2011, pp-311.

[13]. Onkar L. Mahajan, Dr. A.A.Utpat, “Study of effect of solid contaminants in thelubricant on ball bearings vibration”, International conference on Industrial and Mechanical Engineering by IRNet, Aug. 2012