Experimental study of various solid contamination in ball bearings

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Abstract-
In rolling bearings, contamination of lubricant oil by solid particles is one of the main reasons for early bearing failure. In order to deal with this problem, it is fundamental not only the use of reliable techniques concerning detection of solid contamination but also the investigation of the effects of certain contaminant characteristics on bearing performance. Nowadays, non-invasive techniques, such as vibration measurements, are being increasingly used for on-time monitoring of machinery performance. In the elasto hydrodynamic lubrication regime occurring in rolling bearings, very high contact pressures elastically deform the surfaces, giving origin to small elliptical contact areas. The repetitive formation of the elastically deformed contacts eventually leads to surface fatigue .

Keywords- solid contamination , rpm measurement, ball bearing

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1-Introduction -Contaminants in oil-lubricated parts may be either solids or liquids. Hard contaminants can have origin in several sources, such as the environment and handling or else as a consequence of wear itself. They can produce direct effect on lubrication; for instance, in plain bearings, an increase in contaminant concentration can make the oil film thickness to decrease .

Fig .1. ball bearing

Concerning wear mechanisms in rolling contacts, when hard particles go into the interface, surface damage by mechanisms such as denting is inevitable. Dents essentially represent stress concentration sites, which increases the possibilities for the occurrence of spelling, accelerating the failure process . In terms of contaminant particle sizes, some authors state that the critical size is of the order of oil the film thickness, whereas others report that, when particles of sizes larger than the oil film thickness pass through the contact, localized pressure peaks have greater chance of occurring in the contact area. In these tests, surface damage was noticed in the bearings after they had been run in contaminated oil. By means of the same basic procedures previously adopted for vibration analysis, the present study investigates both the dependence of the dynamical response of ball bearings on oil contamination characteristics (contaminant concentration and particle size) and its correlation to wear.

2. Experimental method-Vibration signals were acquired from ball bearings, oil bath lubricated, assembled in an experimental rig. Fig. 5. schematically shows a testing ball bearing in the rig. The applied load was radial, set through a load cell. An accelerometer placed on the bearing housing measured radial vibration. During tests, a mixing system was used to disperse the contaminant particles in the oil bath. A detailed description of the electronic instrumentation can be seen elsewhere . In order to investigate the vibration affected by the bearing wear caused by oil contamination, all the ball bearings tested in contaminated oil were cleaned and retested in clean oil, following the first two sequences of steps previously described. Vibration results of the worn bearings in clean oil were compared to vibration results of the bearings in contaminated oil, in order to find out differences in the vibration trends due to the presence of contaminants alone and due to the bearing wear.

Fig .2. control panel

Fig .3. ball bearing with shaft

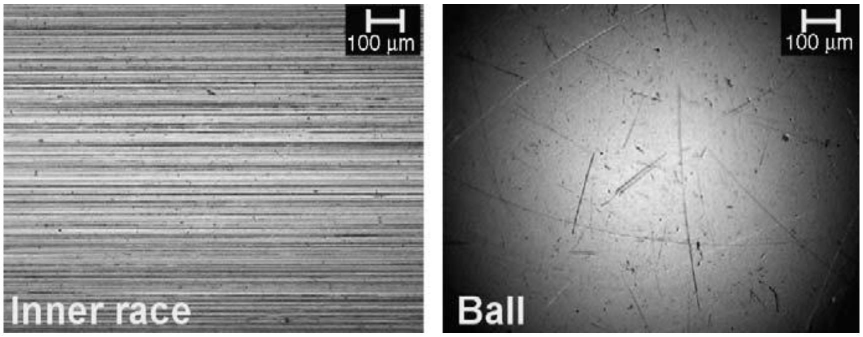

Fig.4. Microscopic appearance of the inner race and ball surfaces.

Fig .5. Experimental setup

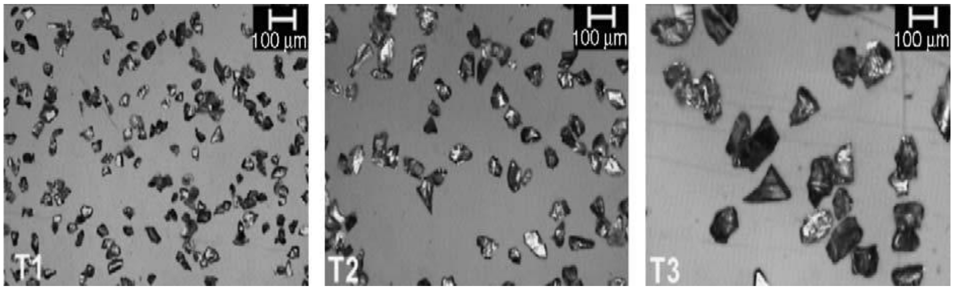

Fig.6. Morphology of the quartz particles used in the tests.

3. Results and calculation-

1- **T_1=37**

W=700N in mid way

Diameter of shaft d=25.4mm

Eccentricity of C.G.outer surface of bearing ,e=0.02mm

RPM of shaft N=650 , Obtain from rpm measurement device

Length of shaft L=400mm

$E=1.96X10^{11}\ N/m^2$

Deflection, $\delta=WL^3/48EI=700X0.4^3X64/48X(1.96X10^{11})\pi(0.0254)^4$

$=7.32X10^{-4}$

Stiffness of shaft,

$$K=\frac{700}{7.32\times10^{-4}}=956031\ N/m$$

Natural frequency of transvers vibration

$$W_n=\sqrt{9.81/7.32\times10^{-4}}$$

$$=115.76\ radian/s$$

$\omega=\frac{2\pi N}{60}=\frac{2\times3.14\times650}{60}$

ω=68.03 radian/s

$r=\frac{\omega}{Wn}$

$r=\frac{68.03}{115.76}$=0.587

$\frac{s}{e}=\frac{r^2}{1-r^2}=\frac{0.587^2}{1-0.587^2}=\frac{0.345\times0.02}{0.655}$

Amplitude of vibration , S=0.0105mm

2-T_2=59

W_n=115.76 radian/s

$\omega=\frac{2\pi N}{60}=\frac{2\times3.14\times1050}{60}$

=109.9 radian/s

$R=\frac{109.9}{115.76}$=0.949

$S=\frac{0.949^2}{1-0.949^2}\times 0.02$

$S=\frac{0.0180}{0.0993}$

Amplitude of vibration , S=0.1810mm

3- **T_3=72**

W_n=115.76 radian/s

$\omega=\frac{2\pi N}{60}=\frac{2\times3.14\times950}{60}$=99.43 radian/s

r=99.43/115.76= 0.858

$s=\frac{0.858^2}{1-0.858^2}\times 0.02$

s=0.0147/0.263

Amplitude of vibration , s=0.055mm

4- T_4=81

W_n=115.76 radian/s

$\omega=\frac{2\pi N}{60}=\frac{2\times3.14\times850}{60}$=88.96 radian/s

r=88.96 /115.76= 0.7685

$$s=\frac{0.7685^2}{1-0.7685^2}\times 0.02$$

s=0.01181/0.4094

Amplitude of vibration , s=0.0288mm

Table 3.1

Sr.no	Solid contamination in micron	Amplitude of vibration
1.	37	0.0105mm
2.	59	0.1810mm
3.	72	0.055mm
4.	81	0.0288mm

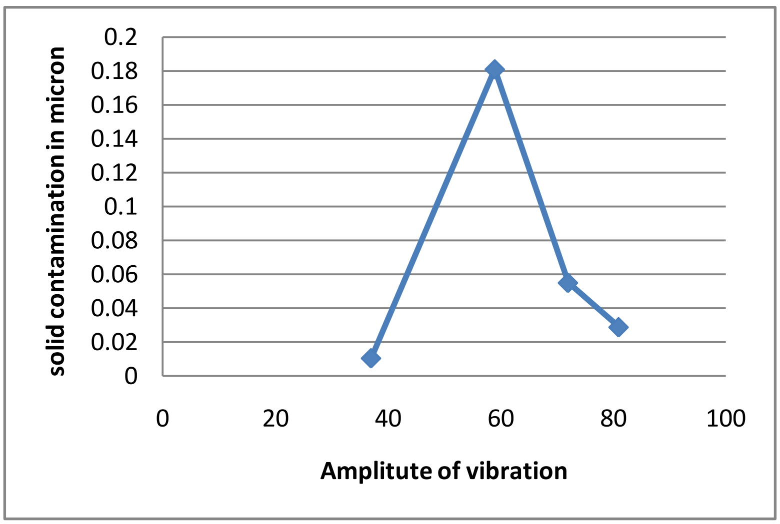

Fig.7. various Amplitude of vibration

4. conclusion- Ball bearings were tested in order to study the effect of oil contamination on vibration level and the correlation of vibration to wear. The method of vibration analysis (rms of high frequency band from 600 to 10,000 Hz) was effective in characterizing the trends in vibration due to oil contamination and due to the consequent bearing wear. The effect of contaminant concentration on vibration was 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.

REFERENCES:-

1 Espejel G. Using affrication models engineering tool. Evolution SKF 2006; 06(2):27–30.

2 Qijun L., Shima M., Yamamoto T. and Sato J. Fretting wear of ball bearing (Part 4). *Tribologists*, *1995*, **40**(4), 1029–1037. 778

3 Maru MM, Serrato-Castillo R, Padovese LR. Detection of solid contamination in rolling bearing operation through mechanical signature analysis. Twelfth international congress on sound and vibration, 11–14 July 2005, Lisbon, Portugal.

4 Carver RE. Procedures in sedimentary petrology. New York: Wiley; 1971.

5 Serrato-Castillo R, Maru MM, Padovese LR. Effect of lubricant oil viscosity and contamination on the mechanical signature of roller bearings. Twelfth international congress on sound and vibration, 11–14 July 2005, Lisbon, Portugal.

6 Hampshire JM, Nash JV, Hollox GE. Materials evaluation by flat washer testing. In: Hoo JJ, editor, Rolling contact fatigue testing of bearing steels ASTM STP 771. American Society for Testing and Materials, 1982. p. 46–66.

7 Jonhston GB, Andersson T, Amerogen E, Voskamp A. Experience of element and full-bearing testing of materials over several years. In: Hoo JJ, editor, Rolling contact fatigue testing of bearing steels, ASTM STP 771. American Society for Testing and Materials, 1982.

8 Maru MM, Serrato-Castillo RS, Padovese LR. Influence of oil contamination on vibration and wear in ball and roller bearings. Ind Lubr Tribol (30): 2007.

9 Study of solid contamination in ball bearing through vibration and wear analyses,MM.Maru,R.S.Castiallo,L.R.Padovese (2006).

10 R. Serrato, M.M. Maru, L.R. Padovese, Effect of lubricant viscosity grade on mechanical vibration of roller bearings, Tribology International 40 (2007) 1270–1275.

11 SKF General Catalogue 6000 EN,November (2005).

12 CousseauT.,Grac-a B.,Campos A., SeabraJ. Experimental measuring procedure forth friction torque in rolling bearings. Lubrication Science, press, 2004 doi:10.1002/ls.115.

13 GoldP, SchmidtA, DickeH,LoosJ ,AssmannC.Viscosity–pressure–temperature behaviour of mineral and synthetic oils.Journal of Synthetic Lubrication 2001;18(1):51–79.

14 Hamrock BJ,DowsonD. Ball bearing lubrication, the elastic hydrodynamics of elliptical contacts.John Wiley&Sons; 1981.