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K.A.I. SHERIFF*, V. HARIHARAN*, T. KANNAN*

ANALYSIS OF SOLID CONTAMINATION IN BALL BEARING THROUGH ACOUSTIC EMISSION SIGNALS

Acoustic emission is one of the effective techniques used for the condition monitoring of rolling element bearings. Contamination is one of the major reasons for bearing early failure due to presence of solid particle in lubricant grease. In most cases, outer race is stationary and the inner race is attached to the rotating assembly. The lubrication is very essential for the bearing to perform under various demanding conditions. The main aim of this project is to analyze the effect of contamination of lubricant by solid particles on the dynamic behavior of rolling bearing. Green sand at three concentration levels 5%, 15%, 25% and different particle sizes 75 µm, 106 µm and 150µm is used to contaminate the lubricant. Experimental tests have been performed for different load and speed condition in good and contaminated ball bearings lubricated with grease. The trends in the amount of AE waves affected by the contamination of the grease were determined. Acoustic emission signals were analyzed in terms of RMS, kurtosis, and peak-peak.

Keywords: Bearing, Solid contamination, Acoustic Emission; Signal parameter

1. Introduction

Rolling element bearing is commonly used in all rotating machineries. The rolling elements of bearing are subjected to failure under various loading condition. Contaminants in the lubricant strongly influence the behavior of ball bearing. The main function of lubricant is to separate moving parts relative to one another for minimization of friction and wear. Maru researched that the contamination of lubricant oil by solid particles is one of the main reasons for early bearing failure. Vibration increases with increase of concentration level. Vibration increases first and decrease with particle size increases [1].

Onkar et.al identified that the bearings contamination of lubricant grease by solid particles the contaminant is added in the lubricant even in a small amount, there is increase in amplitude of vibration signal [2]. Vital Rao et.al identified that vibration spectrum don't give clarity in peak rising in defect frequency where the acoustic emission is superior to vibration in diagnose the defect in bearings [3]. Koulocheris et al. presented that the ball bearings rating life is reduced due to the contaminant's. It can be concluded that wear is more severe when harder particles are used and size of particle [4]. Abdullah et al studied the vibration monitoring of rolling bearings is the most established diagnostic technique for rotating machinery. AE offers earlier fault detection and improved identification capabilities than vibration analysis [5]. Yongyong et al researched that the change in load is not much effective on the AE parameters. The variation in defect size has a very little effect on the AE parameters. The slight change in speed affects the AE parameters greatly [6]. Hariharan et.al, researched that the vibration level is proportional to the contamination level in the ball bearings and found that at 30 per cent of concentration level the bearings failed to rotate. The amount of vibration due to the bearing wear was dependent on the contamination and the presence of particles was proportional to the vibration of the bearing as particle concentration increases [7]. Babak Eftekharnejad et.al, presented that the measurement of AE RMS levels for rotating gear has more sensitive to identification of seeded defects in helical gear than vibration measurement [8]. Rajesh Kumar et.al, identified that the Sharp and high value in amplitude is obtained during the entry and exit of the defect by the taper roller bearing [9]. ZekiKiral and Hira Karagulle suggested that ball bearing with or without a defect have more sensitivity to the parameters like rotational speeds, structure geometry and loading type [10]. Babak Eftekharnejad et.at, studied the relation between acoustic emission and vibration methods for defect identification of naturally damaged bearing. In this Acoustic emission is more sensitive in detecting incipient damage in bearing [11]. Faris Elasha et al researched that the fault detection ability of the AE is based upon the elimination of noise and also in the identification of the higher impact energy frequency region [12]. Elforjaniet al studied that there is a clear correlation between increasing AE energy levels and the natural propagation and formation of bearing defects. They concluded AE has the ability to determine the size of natural defects on bearings [13]. Lingli Cuiet al studied that when the width of the bearing fault is small. The signals are presented as clear single impact. The signals gradually become double impacts with the increasing size of defects [14].

* KONGU ENGINEERING COLLEGE, PERUNDURAI, ERODE, TAMILNADU, INDIA

Corresponding author: ibusheriffmech786@gmail.com

However, the diagnosis of the bearing defect due to solid contamination with different particle size under various concentration levels for different speeds and loads using Acoustic Emission signals has not been investigated so far.In the present work different loading, particle size and speed conditions are considered for good and contaminated roller bearing. Signal Parameters of AE are considered for the analysis of bearing defects.

2. Experimental setup

The experimental setup is fabricated as shown in Fig. 1 to test the bearing. It consists of a shaft with good ball bearings with one end and contamination ball bearing at other end. A motor with pulley arrangement is used to control the speed of the shaft. The ball bearing type 6205 is used for the analysis and setup is run at three speeds 900 rpm, 1500 rpm and 2100 rpm which are named as N_1, N_2 and N_3. The loading arrangements are categorized into four which ranges from 0N to 50N. The acoustic signal from the experimental setup is acquired using microphone. The signals from the microphone are transferred to PC using Data Acquisition Card (DAC). The signal parameter RMS in Pa is obtained using the available "offline math" functions namely "Basic Statistics" and "Classification" in DEWESoft. The results obtained from the experimental work are stored in the Excel format and graphs are plotted to identify the bearing defects.

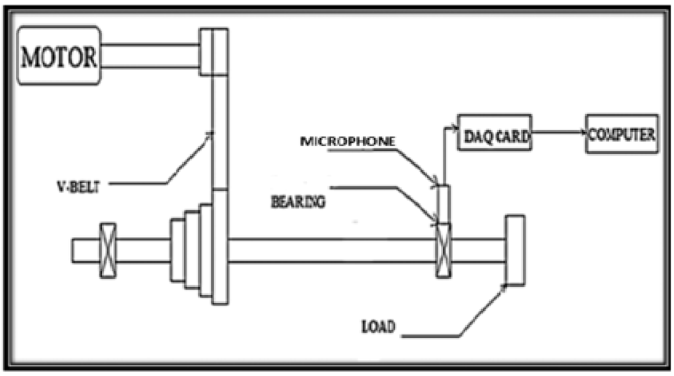

Fig. 1. Experimental set up

3. Result and discussion

The time domain and frequency domain signal for good bearing have been taken by using DEWESOFT at 900, 1500 and 2100 rpm as shown in Figure 2.

RMS

Fig. 3a-c shows the comparison of good bearing (GB) without and with solid contamination of particle size 75 µm, 106 µm and 150 µm respectively at various concentration levels. At lower concentration (5% and 15%) the variation of RMS value were less and similar. At low speed N1 (900 rpm) and 25% of concentration the RMS ranges from 0.084816 Pa to 0.093883 Pa, for speed N2 (1500 rpm) it ranges from 0.085848 Pa to 0.09449 Pa, for speed N3 (2100 rpm) it ranges from 0.086374 Pa to 0.098474 Pa. When compared with three different speeds the RMS value of contaminated bearing is slightly increased than good bearing at 25% of concentration level.

The RMS of good bearing ranges from 0.080346 Pa to 0.092992 Pa. For the particle size of 106 µm and 25% of concentration level the contamination bearing RMS value ranges from 0.08784 Pa to 0.110562 Pa. For the particle size of 150 µm contaminant bearing RMS value ranges from 0.089067 Pa to 0.116475 Pa. The reason for increase in RMS is deformation mechanics [1,2].

KURTOSIS

KURTOSIS value of GB which is operated at a speed of 900 rpm at no load condition is 0.080346. From Fig. 4a-c it is cleared that the KURTOSIS value for 5% of contamination level of bearing is increased by 3.256% at 0 kg load, 3.256% at 1 kg load, 4.27% at 3 kg, and 3.26% at 5 kg load when compared to good bearing respectively.

When the particle size is increased to 106 µm at 5% contamination level, the KURTOSIS value is increased by 30.1% compare to GB at 0 kg load, and when the load is increased to 5 kg the KURTOSIS value is increased by 9.395% compare to GB. When the particle size is increased to 150 µm the KURTOSIS value is increased by 13.55% compared to GB value at 0 kg

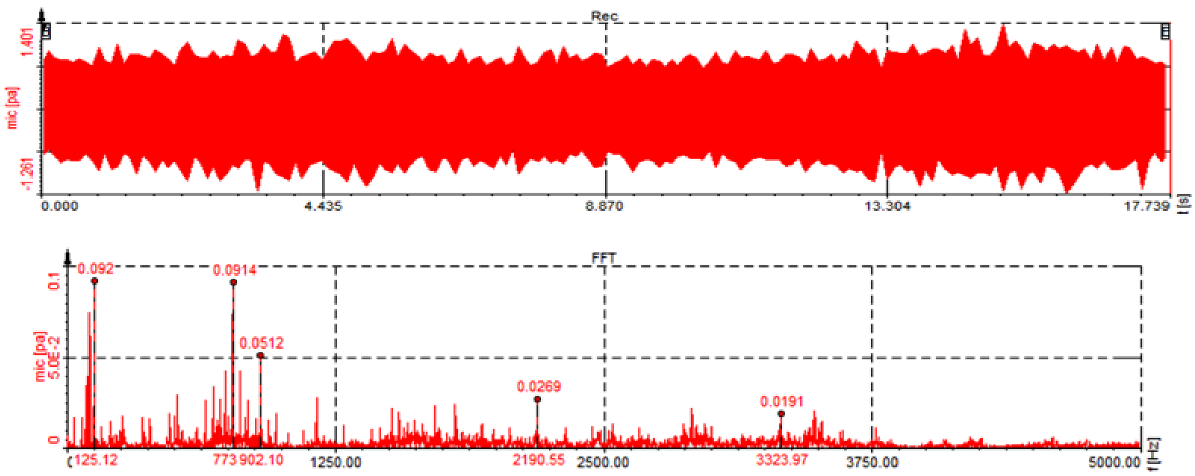

Fig. 2. AE signal of Good bearing

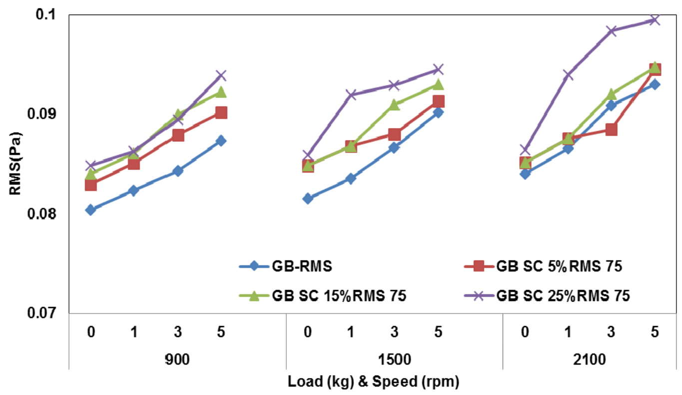

Fig. 3a. RMS graph for 75 µm particle size

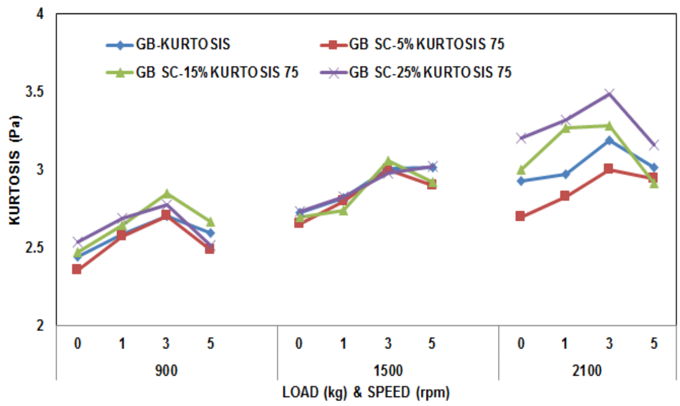

Fig. 4a. KURTOSIS graph for 75 µm particle size

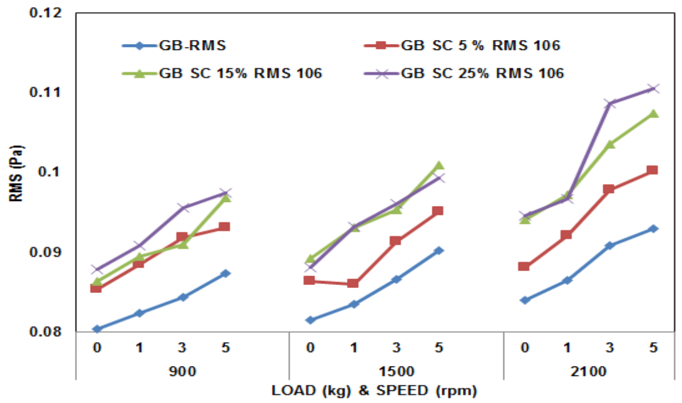

Fig. 3b. RMS graph for 106 µm particle size

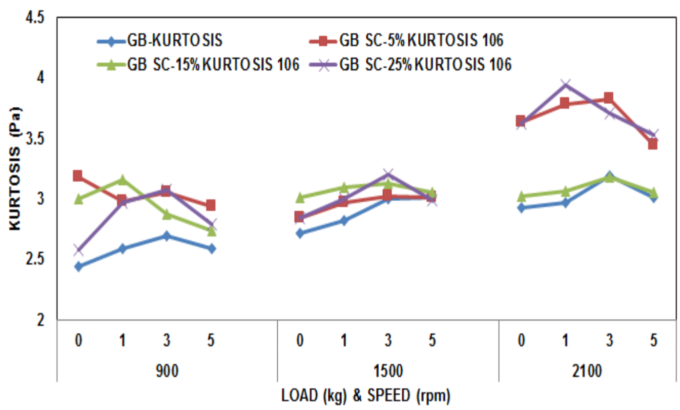

Fig. 4b. KURTOSIS graph for 106 µm particle size

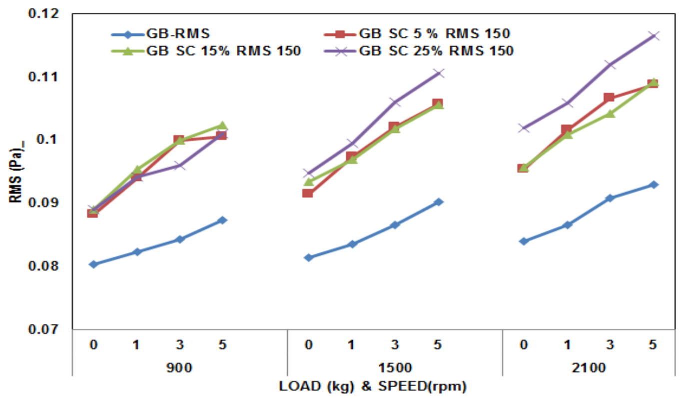

Fig. 3c. RMS graph for 150 µm particle size

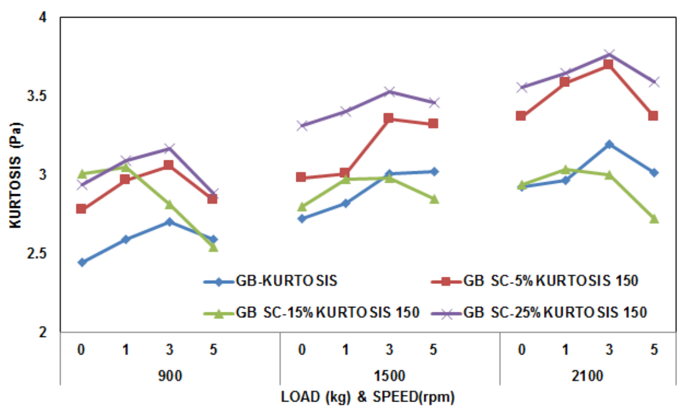

Fig. 4c. KURTOSIS graph for 150 µm particle size

load, and when the load is increased to 5 kg the KURTOSIS value is increased by 9.39% compared to GB value. This shows that when particles size increased KURTOSIS value first increases and then decreases.

When the speed is increased to 900 rpm to 2100 rpm for 0 kg load KURTOSIS value of GB value is increased by 19.6% and for the particle size of 75 µm at 0 kg load the KURTOSIS value is increased by 14.43% for 5 kg load it is found to increase by 18.31%. When the speed is increased to 900 rpm to 2100 rpm for 0 kg load KURTOSIS value of GB value is increased by 19.6% and for the particle size of 150 µm at 0 kg load the KURTOSIS value is increased by 21.3% for 5 kg load it is found to increase by 18.8%. From the above results the Kurtosis value first increases and then decreases, this is due to increase in speed of bearing the contamination thrown off due to acceleration [4,6,10].

PEAK-PEAK

When the particle size is increases from 75 µm to 106 µm at 5% of contamination level the PEAK-PEAK value is increased by 32% compare to GB signal at 0 kg load, and when the load is increased to 5 kg the PEAK-PEAK value is increased by 38.5%compare to GB value. When the particle size is increased to 150 µm the PEAK-PEAK value is increased by 69.4% compare to GB value at 0 kg load, and when the load is increased to 5 kg the PEAK-PEAK value is increased by 58.6% compare to GB

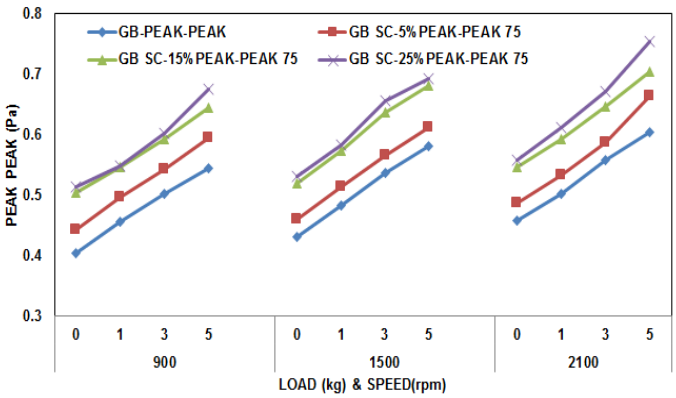

Fig. 5a. PEAK TO PEAK graph for 75 µm particle size

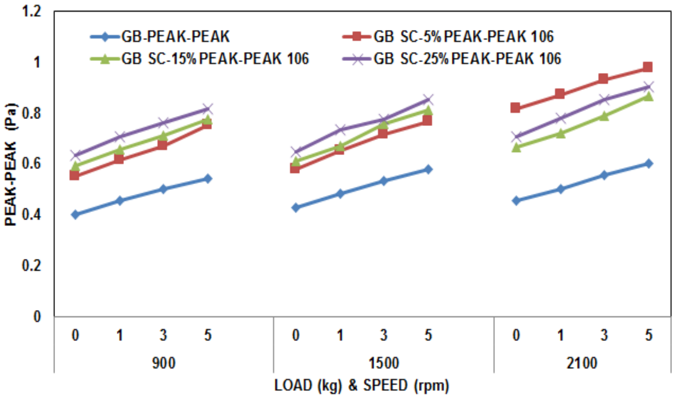

Fig. 5b. PEAK TO PEAK graph for 106 µm particle size

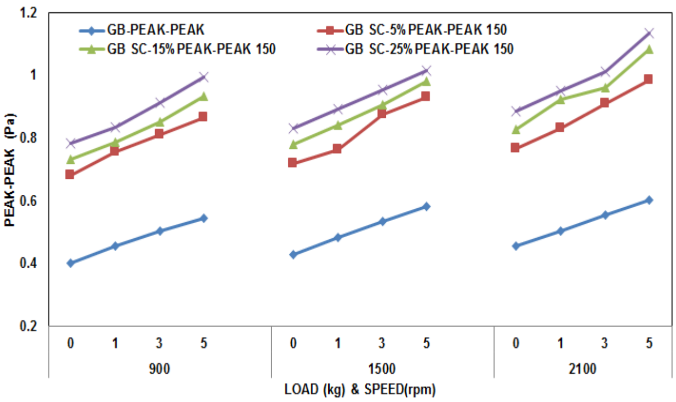

Fig. 5c. PEAK TO PEAK graph for 150 µm particle size

signal. This shows that when particles size increased PEAK-PEAK value also increases [10].

At 25% of concentration level the PEAK-PEAK value ranges from 0.78338 to 1.13535 Pa at 150 µm. From the Fig. 5a-c, comparing the three concentration levels 5%, 15%, and 25%. Higher concentration level of 25% has the high PEAK-PEAK value. Comparing the three particle size75 µm, 106 µm and150 µm. At 150 µm PEAK-PEAK value is high comparing to other particle size. Higher concentration level and higher particle size have the more effect in bearing [1,4].

4. Conclusion

The solid contaminated bearing signals are compared with good bearing signals for various speed and load conditions under different concentration level and different particle sizes. The RMS value and PEAK TO PEAK value is increased from 2.5% to 17.33% and 9.92% to 63.35% respectively when compared to the good bearing. From the above analysis it is cleared that the energy level is more, since wear defects occurred on the surface of bearing parts by contaminants. The higher particle size of contaminant affects the bearing performance more than the other two particle sizes. Also the Kurtosis value first increases and then decreases, this is due to increase in speed of bearing the contamination thrown off due to acceleration.

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