© Applied Science Innovations Pvt. Ltd., India Carbon – Sci. Tech. 6 / 3 (2014) 43 - 46

Carbon – Science and Technology

ISSN 0974 – 0546

http://www.applied-science-innovations.com

ARTICLE

Received : 13/09/2014, Accepted : 25/10/2014

Vibration analysis of angular contact ball bearing operated with copper oxide nanoparticle mixed ISO VG 68 lubricating oil

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The purpose of this paper is to investigate the effect of CuO nanoparticles on lubricating oil and vibration reduction in angular contact ball bearing. CuO nanoparticles are synthesized by using chemical method and characteristic studies done in XRD and TEM. CuO nanoparticles size achieved in the range 26 - 30 nm. The nanoparticles concentration of 0.2 wt. % added into the lubricant (ISO VG 68). The test rig setup consists of angular contact ball bearing operated by AC motor with speed controller. The bearing (New and outer defect) vibrations measured using base oil and CuO mixed oil.

1. INTRODUCTION: Vibratory motion is a characteristic of all types of machinery, particularly rotating machinery. There is great interest in measuring and quantifying this motion because it is indicative of the state and health of the machinery. The test rig was fabricated, which consist of angular contact ball bearing measuring the vibration of a particular piece of machinery is to mount an accelerometer and measure the accelerations produced by the vibration [1].

There are numerous accelerometers on the market outputting both digital and analog signals that can be captured by a computer using DAQ (Data Acquisition Card). Then, using the LabVIEW program, this data is parsed, analysed and used to determine if the machinery is operating properly. Data interpretation is done by using FFT (Fast Fourier Transform). The state of the machinery can be determined by comparing with the values specified by ISO standards.

Based on the mechanical application friction and wear are two major reasons to vibration of various machine components, such as bearings, camshafts, piston, gearbox, lead screw and compressor [2]. A large number of papers have reported that the addition of nanoparticles to lubricant was effective in reducing wear and friction [3-11]. Among different nano-particles available, oxides of Copper was preferred as an additive to most of lubricating oil because of low cost, high thermal conductivity and low coefficient of friction [12-17]. Many studies have been reported that copper oxide nano-particle operates in the lubricant temperature of 100 - 150°C and even higher than that with high loading conditions [12, 16, 18, 19]. Dispersion of nano copper oxide (CuO) particle with the lubricant enhances viscosity, anti friction, anti wear and thermal conductivity of base fluid compared to TiO_2, fullerene, nano diamond, ZnO and ZrO_2 [10, 11, 18 - 24]. Friction and surface damage caused by high temperatures and pressures can be reduced by applying extreme pressure (EP) and antiwear (AW) additives.

In this research the CuO nanoparticles were purchased and added as an additive into the ISO VG 68 oil. Vibration comparison study was carried out with base oil and nano CuO mixed oil.

2. METHODOLOGY:

2.1 Method of nanoparticles dispersion: Copper oxide nanoparticles was purchased from Nanoshell Company in USA and dispersed primarily by a commutation ball impactor and then prepared by the Tween 20 (Combination of polyoxyethylene sorbitol ester with ethylene oxide, sorbitol, and lauric acid produced by Sigma Aldrich., USA) modification in the laboratory.

Tween 20 and ethanol had been mixed and heated to 70°C for 3 h with stirring. Before that an appropriate amount of copper oxide nanoparticles were added and dispersed with 20 kHz Ultrasound sonication probe for 30 min to achieve a stabilized liquid. The precipitates were rinsed thoroughly with ethanol by filtering and the Tween 20 surface modified copper oxide nanoparticles would be obtained finally. The 0.2 wt.% of surface modified copper oxide nanoparticles were dispersed in the ISO VG 68 lubricating oil with sonication for 30 min. The physical and chemical properties of ISO VG 68 are shown in Table (1).

Table (1): Typical properties

Properties	ISO VG 68
Density at 29.5°C	0.85
Viscosity index, min	115
KV at 40 °C mm^2/s	68
KV at 100 °C mm^2/s	9.3
Flash Point °C (PMCC), min	254
Pour Point °C	-36

2.2 Characterization: The XRD (Model: Shimadzu XRD 6000) pattern of the purchased CuO nanoparticles in Figure (1a) shows that the diffraction peaks match well with patterns (JCPDF Card no. 05-661). The average crystallite size (D) has been calculated from the line broadening using Scherrer's relation : $D = 0.9\ \lambda / B \cos\theta$, where λ is the wavelength of X-ray and B is full width of half maximum (FWHM) [4, 5].

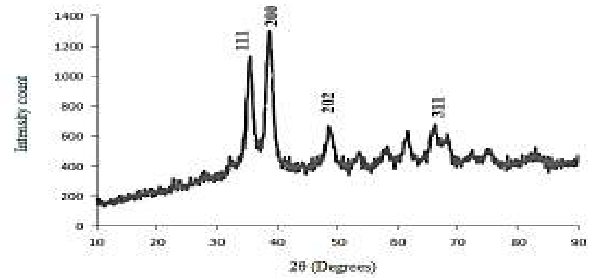

Figure (1a): XRD pattern of CuO nanoparticles

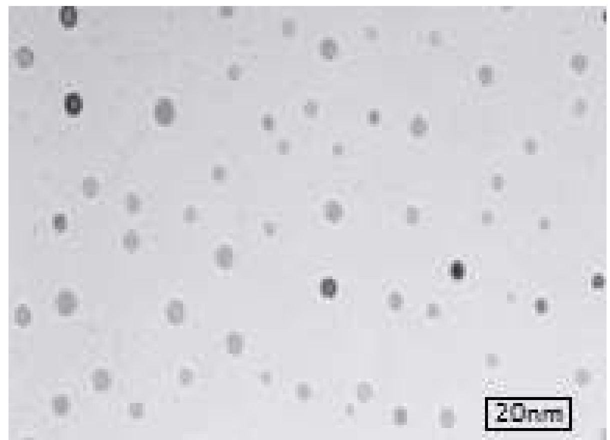

Figure (1b): TEM morphologies

The average crystallite size of CuO nanoparticles was found to be 26 - 30 nm (Using Scherrer formula). The Figure (1b) shows the typical TEM image and uniform dispersion of CuO nanoparticles performed with JEOL JEM 2100.

2.3 Experiment setup: The experiments were carried out in the angular contact ball bearing in the test rig setup shown in Figure (2). The experiments were carried out with new ball bearing (SKF 7304), ball defected and outer case defected bearing with the constant running speed of 1500 rpm. The vibration data were collected in PC with the help of accelerometer [6, 7] and NI-cDAQ-9172 device.

Bearing vibrations were acquired with ISO VG 68 oil in no load, 500N and 750N loading condition at the constant speed of 500 rpm. The experiments carried out with 0.2 wt.%wt copper oxide nano particle mixed lubricant as per the above said bearing conditions. All the experiments were repeated for three times and average values taken and presented as a graph.

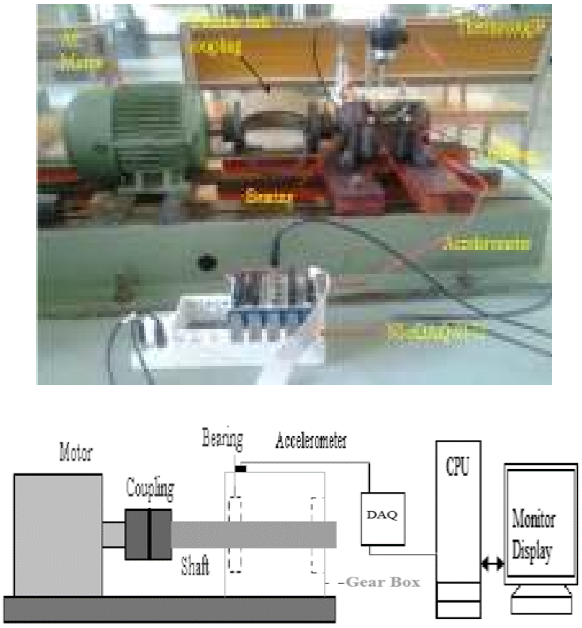

Figure (2) Test rig setup

3. RESULTS AND DISCUSSION:

3.1 Vibration Measurement: The angular contact bearing operated with both base oil and 0.2 wt.% nano-CuO mixed oil. The Figure (3a) shows the vibration amplitude of new angular contact bearing with constant speed range [8]. The amplitude measurement and vibration level is calibrated in that bearing with the help of accelerometer sensor. In Figure (3b) show that defected bearing is operated with base oil and 0.2 wt.% nano-CuO mixed oil. The graph indicates that use of nano-CuO mixed oil had shown better vibration reduction level.

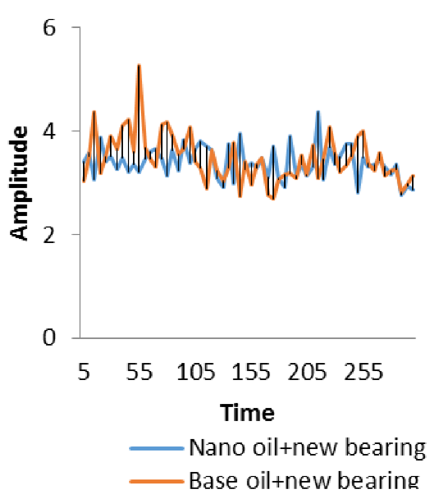

Figure (3a): Amplitude of vibration for new bearing

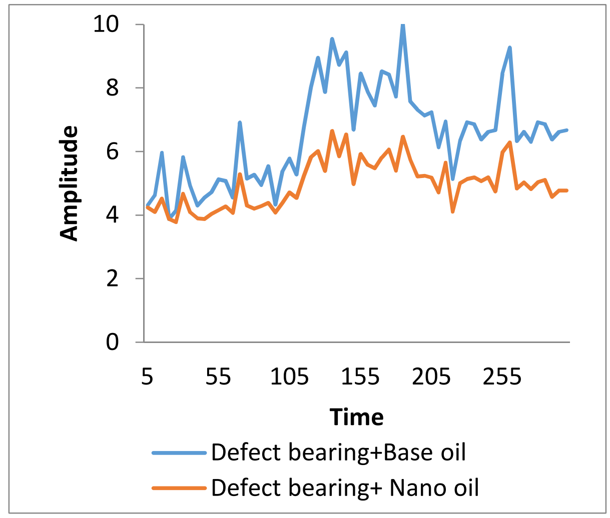

Figure (3b): Amplitude of vibration for defected bearing

3.2 Temperature Measurement: The temperature values are calibrated with the help of thermocouple. In this test new bearing and defect bearing were tested using both base oil and nano – CuO mixed oil. Figure (4) shows the effect of oil temperature on the new bearing and defect bearing with and without nanoparticles into the base oil [9]. The new and defect bearing curves of base oil rise rapidly with the increase of oil temperature, while the curves of oil containing Cu nanoparticles rise slowly and stably.

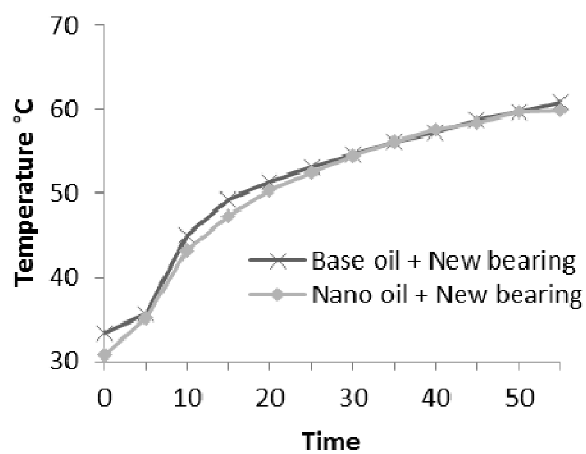

Figure (4a): New Bearing Temperature as function of time

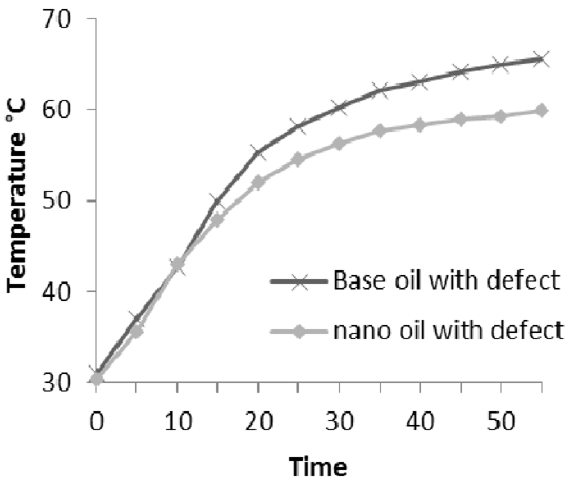

Figure (4b): Defect Bearing Temperature as function of time

4. Conclusions: 0.2 wt.% CuO nanoparticles were used as additives in lubricating oil exhibit good friction reduction behaviour. The vibration analysis of angular contact bearing reveals that, in new and defected bearing an amplitude of vibration was reduced by 19.59 % and 33.72 % respectively as compared to the base oil. Temperature of new bearing and defective was reduced by 3 % and 5 % respectively, as compared to the oils without nanoparticles. 0.2 wt.% of nano particle in the ISO VG 68 lubricant reduces the amplitude of vibration and temperature of lubricant to the certain extent.

References :

[1] Dibya Prakash Jena, Manpreet Singh, and Rajesh Kumar, Meas. Science Rev. 12/4 (2012).

[2] Dan Li, WenjieXie and Wenjun Fang, Nanoscale Research Letters, 6 (2011) 373.

[3] A. Hernandez Battez, R. Gonzalez, D. Felgueroso, and J. E. Fern´andez, Wear 263 (2007) 1568.

[4] T. Theivasanthi, M. Algar, Arch. of Phy. Research 1 (2010) 112.

[5] Y. Y. Wu, W. C. Tsui, T. C. Liu, Wear 262 (2007) 819.

[6] E. F. Rico, I. Minondo, D. G. Cuervo, Wear 262 (2007) 1399.

[7] S. Qiu, J. Dong, G. Chen, Wear 230 (1999) 35.

[8] Hsiao Yeh Chu, Wen Chen Hsu, and Jen Fin Lin, Wear 268 (2010) 960.

[9] Yujin Hwang, Changgun Lee, Youngmin Choi, Seongir Cheong, Doohyun Kim, Kwangho Lee, Jaekeun Lee and Soo Hyung Kim, Journal of Mechanical Science and Technology 25 (2011) 2853.

[10] A. Hern´andez Battez, R. Gonz´alez, J. L. Viesca, J. E. Fern´andez, J. M. Dıaz Fern´andez, A. Machadoc, R. Choud, J. Riba, Wear 265 (2008) 422.

[11] Kwangho Lee, Yujin Hwang, Seongir Cheong, Youngmin Choi, Laeun Kwon, Jaekeun Lee, and Soo Hyung Kim, Tribol. Lett. 35 (2009) 127.

[12] M. Nabeel Rashin, J. Hemalatha, Exp. Therm. Fluid Sci. 38 (2013) 67.

[13] Zhang Qiu-li, Yang Zhi-mao, Ding Bing-jun, Lan Xin-zhe, Guo Ying-juan, Trans. of Non Ferr. Soci. of China 20 (2010) 240.

[14] Y. Aparna, K. Venkateswara Rao, P. Srinivasa Subbarao, J. Nano-Electron. Phys. 4 (2012) 03005.

[15] Jingfang Zhou, ZhishenWu, Zhijun Zhang, Weimin Liu and Qunji Xue, Tribo. Letters 8 (2000) 213.

[16] M. Kole, T. K. Dey, Int. J. Therm. Sci. 50 (2011) 1741.

[17] Gu Cai-xiang, Zhu Guan-jun, Li Lei, Tian Xiao-yu and Zhu Guang-yao, J. Marine. Sci. Appl. 8 (2009) 71.

[18] Dan Li, Wenjie Xie and Wenjun Fang, Nanosc. Resear. Lett. 6 (2011) 1.

[19] Madhusree Kole, T. K. Dey, Exper. Ther. and Fluid. Sci. 35 (2011) 1490.

[20] Pullela K Sarma, Vadapalli Srinivas, Vedula Dharma Rao, and Ayyagari Kiran Kumar, Nanoscale Research Letters 6 (2011) 1.

[21] Yuh-Yih Wu, Mu-Jung Kao, Industri. Lub. and Tribo. 63 (2011) 440.

[22] De-Xing Peng, Yuan Kang, Shih-Kang Chen, Fu-Chun Shu, Yeon-Pun Chang, Industri. Lub. and Tribo. 62 (2010) 341.

[23] De-Xing Peng, Yuan Kang, Cheng-Hsien Chen, Shih-Kang Chen Fu-chun Shu, Industri. Lub. and Tribo. 6 (2009) 213.

[24] B. S. Shenoy, K. G. Binu, R. Pai, D. S. Rao, R. S. Pai, Tribo. Inter. 45 (2012) 38.