VIBRATION CHARACTERISTIC ON BALL BEARING OPERATED WITH HEXAGONAL BORON NITRIDE (HBN) NANOPARTICLE MIXED WITH DIESEL ENGINE OIL

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1. ABSTRACT

This paper presents the investigation on vibration characteristic on ball bearing operated with hexagonal boron nitride (hBN) nanoparticle mixed with diesel engine oil. Machine components including gears and bearings operates at high speed and high load condition. These extreme condition will lead to the high pressure and vibration on the working system. Thus, lubricant is needed to overcome the increase in pressure, temperature and also vibration. In this paper, the hBN nanoparticle was added as an additive into the SAE 15W40 diesel engine oil. Comparison study is also carried out with based engine oil and nanoparticles hBN mixed engine oil for different concentration. From this proposed study, the vibration characteristic can be investigated and performance of diesel engine oil with hBN nanoparticle can also be determined. The results show that the addition of hBN nanoparticle in the lubricant functioning effectively in reducing vibrations of bearing in diesel engine oil.

2. INTRODUCTION

Studies have proved that the right lubricant needs to be used in order to reduce the friction, wear, operating temperature, corrosion of metal surfaces, and assists in keeping contaminants out of the system. Lubricants have many properties that can be mixed and matched the operating needs. Due to that reason, searching for new additives in the lubricant has becomes one of the most important technology from the researchers because the additives present in lubricant can reduce the friction and wear between the contacting surfaces [1]. The past research used the copper nanoparticles as additives to prevent severe anti-wear, load-carrying and friction reduction performances added in diesel engine oil. These findings were followed by other nanoparticles like zirconia/silica (ZrO_3/SiO_2) composite, copper oxide (CuO), titanium oxide (TiO_2) and also nano-diamond. All these nanoparticles were observed as efficient in improving tribological properties [2-3]. This nano-oil also actively reduced the wear rate of materials and this shows good quantitative agreement with coefficient of friction by dispersing the nanoparticles in conventional diesel engine oil. Hexagonal boron nitride was widely uses as lubricant additive for high temperature lubrication. Other than that, it can also uses as electrical insulators, standard parts materials, heat radiation material, aeronautics and space application [4]. This shows that the crystal structure of this element make it can be used in widely range of field. There has been a few published papers shows that this type of nanoparticles has significant reduction in wear and friction. However, until now, none of this research has provides clarification of the reduction in vibration amplitude. Vibration method is one way of condition monitoring for the machine and also it is more versatile as it can reveal wider range of faults for the early deterioration or malfunction in machinery. Thus, in this paper, the vibration measurement technique is applied to obtain the amplitude of the ball bearing operated with hBN nanoparticles mixed with engine diesel oil.

3. METHODOLOGY

An experimental setup is designed and fabricated to determine the vibration measurement on ball bearing operated with hBN nanoparticles added with diesel engine oil. Fig. 1 depicts the schematic layout of the measurement system.

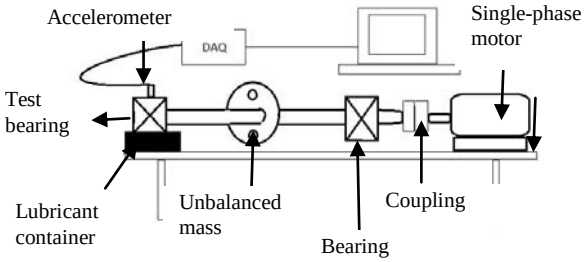

Fig. 1 The schematic layout of the measurement system

The main components of the experimental setup are motor, flexible coupling, ball bearing and container. The shaft is connected to the DC motor using flexible coupling and also supported by deep groove ball bearing. All the components are mounted on steel channel which is welded together to avoid the unwanted vibration. The steel channel has the heavy-duty caster for easy to mobilize around. A DC electric motor of 1 Horse Power (Volt-240V, Current-2.3 A) with operating speed of 1440 rpm is used in the experiment setup. An accelerometer was mounted on top of the bearing housing is connected with data by acquisition device DATA PHYSIC SignalCalc Analyser connected via USB port of the PC. The mixture of nanoparticles in the diesel engine oil was homogenized using an ultrasonic homogenizer for 30 minutes. Different concentrations (0%,

0.2%, 0.5%, 1.0%) of hBN nanoparticles was dispersed into SAE 15W40 diesel engine oil. This mixture was poured into lubricant container until the ball bearing was partially submerged by the lubricants and vibration signals were acquired. Then, the raw data was converted by Fast Fourier Transform (FFT) in MATLAB software to acquire the frequency waveform. The experiment were conducted with three different types of bearing which were new bearing, inner defect bearing and outer defect bearing with the different concentration of nanoparticles. Several loads were located at different places in order to introduce the unbalanced condition.

4. RESULT AND DISCUSSION

Table 1 shows the results obtained for a new bearing, outer defect bearing and inner defect bearing from the test.

Table 1 Acceleration values of the different types of bearing

Types of bearing	Acceleration (ms^{-2})			
	Vol.Concentration (%)			
	0.0	0.2	0.5	1.0
New bearing	0.1630	0.1410	0.2760	0.2790
Outer defect	0.0661	0.0360	0.0839	0.1920
Inner defect	0.0154	0.0150	0.0574	0.0701

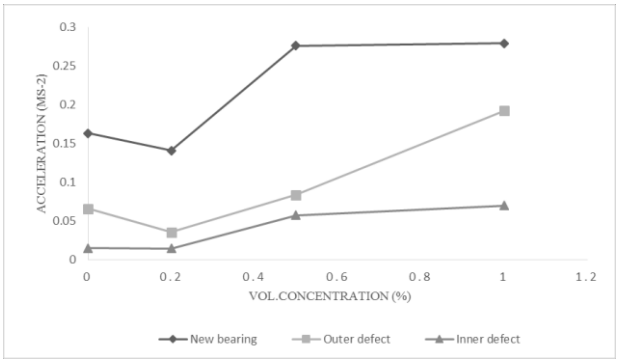

Fig. 2 Amplitude of vibration as a function of nanoparticles concentration

As shown in Fig. 2, the 0.2% vol. concentration of nanoparticles is the best concentration in reducing vibration for all type of different bearings compared to other concentration. The significant reduction in amplitude for 0.2% of concentration was obtained compared to base lubricant in which reduction of 13.5% for new bearing, 45.5% for outer defect bearing and 2.6% for inner defect bearing. The amplitude of the mixed nano-lubricants was decreased compared to the base lubricant because of the formation of full film lubrication regime formed around the ball bearing. Also, vibration performances of this mixed lubricants are slightly better than the base lubricant due to the different in particles sizes formed. The significant peaks for outer and inner defect of bearings can be observed at 4.5X and 5.4X as shown in Fig. 3 and 4.

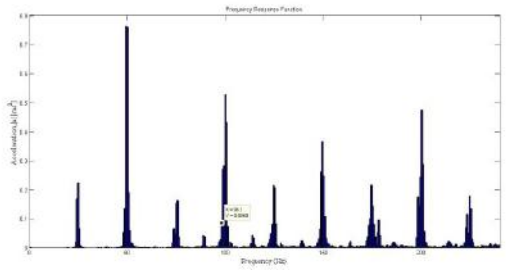

Fig. 3 The outer defect significant peaks

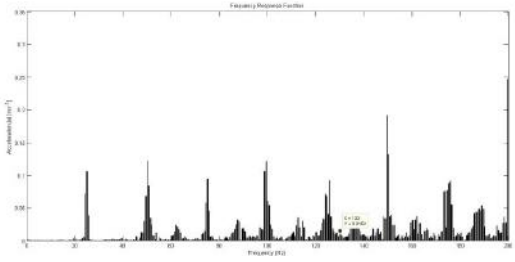

Fig. 4 The inner defect significant peaks

5. CONCLUSION

The hBN nanoparticles mixed lubricants can function effectively in reducing the vibration measurement in the ball bearing in order to decrease the emission and better fuel efficiency.

6. ACKNOWLEDGEMENT

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REFERENCES

[1] M.I.H.C. Abdullah, M.F.B. Abdollah, H. Amiruddin, N.Tamaldin, N.R. Mat Nuri, Effect of Hbn/Al2O3 Nanoparticle Additive on the Tribological Performance of Engine Oil, Jurnal Teknologi (Sciences and Engineering), 66:3 (2014), pp. 1-6.

[2] Prakash, E., Siva Kumar, K., and Muthu Kumar, K. (2013). Experimental studies on vibration characteristics on ball bearing operated with cooper oxide nano particle mixed lubricant. I.nternational Journal of Engineering and Technology, 5(5), 4127-4130, 2013.

[3] S.M. Muzakkir, "Design and Development of Experimental setup for Direct Acting Overhead Camshaft (DOHC) Valve System", vol.5, no.3, 2013.

[4] C.V. Vazhappilly, V.K. Manoj Kumar, C.R. Praveen Raj, P. Kamalesan, Experimental Analysis of Vibration of Ball Bearing Considering Solid Contaminants in Lubricants, International Journal of Engineering Research and Applications, 3(5),pp.1576-1580, 2013.