Effect of hexagonal boron nitride additive on the vibrations of ball bearing

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Keywords: Ball bearing; Vibration reduction; nanoparticles

ABSTRACT – This paper presents a study on the performances of the hexagonal boron nitride (hBN) nanoparticles additive in reducing the vibration amplitude on ball bearing. The nano-oil was prepared by mixing hBN powder with SAE 15W40 diesel engine oil at different volume concentrations from 0.2 to 1.0 vol.% using an ultrasonic homogenizer. The vibration test was conducted with the experimental test rig consist of new and defected bearings. The experimental results show that the 0.2 vol.% of hBN could reduced the vibration amplitude of new and defected bearings effectively as compared to the other concentrations. In summary, it is found that the hBN mixed lubricant has a potential in reducing the vibration amplitude of new and defected bearing.

1. INTRODUCTION

Nowadays, searching for new additives in the lubricant have becomes one of the most important technologies 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 [2]. Then, this finding was followed by other nanoparticles like zirconia/silica (ZrO_3/SiO_2) composite, copper oxide (CuO), titanium oxide (TiO_2) and nano-diamond. All these nanoparticles have shown a good performance in improving tribology characteristics [3-4]. Hexagonal boron nitride was widely uses as lubricant additive for high temperature lubrication [5-6]. Other than that, it also can be used as an electrical insulator, standard parts materials, heat radiation material, aeronautics and space application. The crystal structure of this element makes it able to use in widely range of field. However, until now, none of these studies provide clarification of the reduction in vibration amplitude by adding nanoparticles in lubricant. Vibration monitoring is one way of condition monitoring for the machine and it is more versatile as it can reveal wider range of faults for the early deterioration or malfunction in machinery particularly in rotating components [7-8]. 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.

2. METHODOLOGY

The hBN nanoparticles is in the form of white powder was dispersed into the conventional diesel engine oil namely SAE 15W40. The mixture was homogenised using an ultrasonic homogenizer for 30. The sample is varying from 0.0, 0.2, 0.5 and 1.0 vol.% of concentration of hBN. The vibration test rig as shown in Figure 1 consists of single phase motor, lubricant container and the tested bearing. The accelerometer was placed on top of the housing bearing to capture the signal from the bearing and the data was analysed using the DATA PHYSIC.

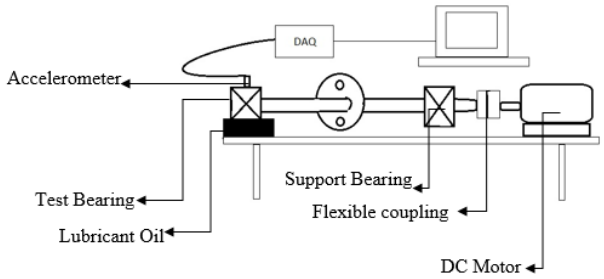


Figure 1 The vibration experimental test rig

3. RESULTS AND DISCUSSION

From Figure 2, it shows that the 0.2 vol.% concentration of hBN is the optimum concentration in reducing vibration for all type of different bearings condition compared to other concentration. Figure 3 shows the reduction of vibration amplitude in ball bearing mixed lubricant. The new bearing shows 34% of vibration reduction from base lubricant, for the outer defected, it shows 20% of reduction in amplitude and lastly for the inner defected bearing it shows that the amplitude reduce was 36% compared to the base lubricant.

The amplitude of the mixed nano-lubricants was decreasing compared to the base lubricant because of the formation of full film lubrication regime formed around the ball bearing [2]. Also, the presence of nanoparticles itself could reduce the vibration amplitude. This phenomenon is known as friction-induced vibration which is widespread phenomena in technical device and

engineering systems. The scanning electron microscopy (SEM) with addition of energy-dispersive X-ray (EDX) spectrum of the hBN nanoparticles with 0.0 vol.% and 0.2 vol.% of concentration is shown in Figure 4 to compare the boron element that exist inside the bearing.

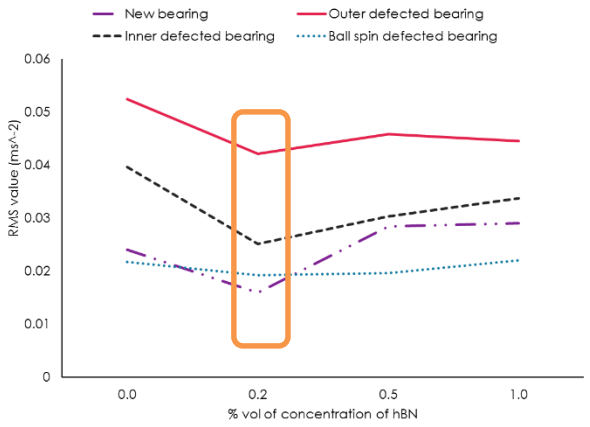


Figure 2 Vibration amplitude for new and defected bearings

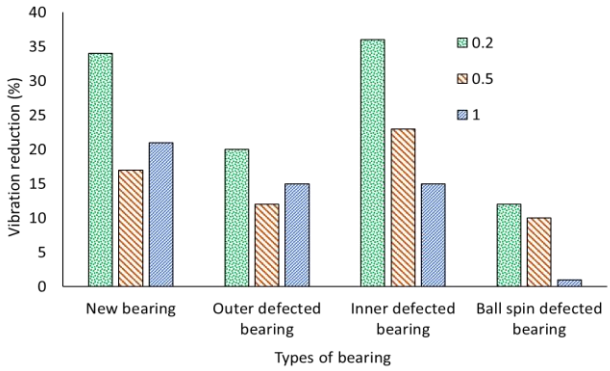
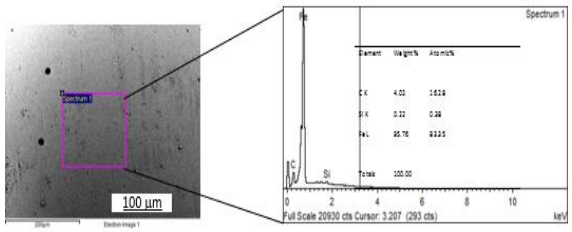
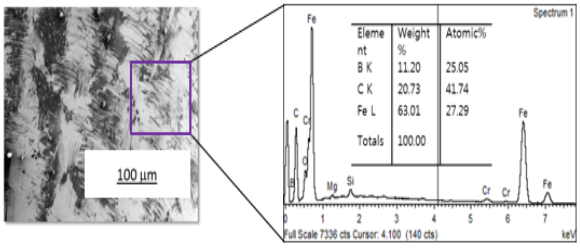


Figure 3 the reduction of vibration amplitude in ball bearing mixed lubricant



(a)



(b)

Figure 4 SEM micrograph and EDX spectrum for (a) 0.0 vol.% and (b) 0.2 vol.% of hBN concentration.

The results show that the boron element coexits inside 0.2 vol.% of hBN concentration of hBN. Meanwhile, for 0.0 vol.% of hBN concentration, there is carbon and iron element only. However, this lubrication mechanism can only be observed with the lowest value of volume concentration because when the percentage of volume concentration of hBN increased the agglomeration occurs in which the elements are sticking to one another as shown in Figure 4. This phenomenon can clearly understand when the volume of concentration increases from 0.5 vol.% to 1.0 vol.%. This agglomeration will buckle up and it will reduce the ability of rolling effect on the surface. Agglomeration will reduce the function of nanoparticles as a friction modifier. Their advantages are the manometer size allows them to enter easily the contact area, like molecules so that it will immediately efficient even at ambient temperature, so it can change the mending effect to the rolling effect when two contact surfaces are in touch. The nanoparticles suspended in lubricating oil do the role of ball bearings between friction surfaces. It is also make a protective film to some extent by coating the rough friction surfaces.

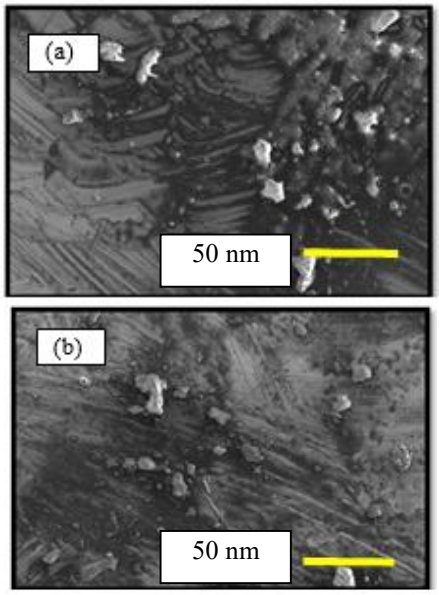


Figure 4 SEM micrograph of (a) 0.5 vol.% and (b) 1.0 vol.% of hBN concentration

4. CONCLUSION

The vibration performance of the hBN nanoparticles has been investigated. The addition of hBN nanoparticle into the base oil was found to have good influence on the frequency and vibration amplitude responses especially for 0.2 vol% of concentration. The results show that the 0.2 vol% of concentration functioning effectively in reducing the amplitude of new and defected bearings compared to the other volume concentration.

ACKNOWLEDGMENT

The research is supported by the Ministry of Education, Malaysia (Grant no. RAGS/1/2014/TK01/FKM/B00066).

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