Applied Mechanics and Materials Vol. 607 (2014) pp 70-73
Online available since 2014/Jul/28 at www.scientific.net

doi:10.4028/www.scientific.net/AMM.607.70

Improving engine oil properties by dispersion of hBN/Al_2O_3 nanoparticles

Muhammad Ilman Hakimi Chua Abdullah[2,a], Mohd Fadzli Bin Abdollah[1,2,b*], Hilmi Amiruddin[1,2,c], Noreffendy Tamaldin[1,2,d], Nur Rashid Mat Nuri[1,3,e], Masjuki Hassan[4,f], S.A. Rafeq[1,2,g]

[1]Centre for Advanced Research on Energy, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

[2]Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

[3]Faculty of Engineering Technology, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

[4]Faculty of Engineering, University of Malaysia, 50603 Kuala Lumpur, Malaysia.

[a]kimi_ilmn@yahoo.com, [b]mohdfadzli@utem.edu.my, [c]hilmi@utem.edu.my, [d]noreffendy@utem.edu.my, [e]nrashid@utem.edu.my, [f]masjuki@um.edu.my, [g]rafeq@utem.edu.my

Keywords: hBN, Al_2O_3, nanoparticles, oil properties

Abstract. This paper provides oil properties study of conventional diesel engine oil enriched with hBN/Al_2O_3 nanoparticles. In this study, an optimal composition (0.5 vol.%) of hBN and Al_2O_3 nanoparticles separately dispersed in SAE 15W40 diesel engine oil by sonication technique. The oil properties were studied by measuring the Viscosity Index (VI), Total Acid Number (TAN), Total Base Number (TBN) and flash point temperature. The results reveal that the nano-oil with hBN nanoparticles could improves or at least maintain the key lubrication properties, though the TAN value is slightly increased. The results presented here may facilitate improvements in the conventional diesel engine oil performance.

Introduction

For a decade, lubricants become a major contribution in reducing wear of machineries and automotive parts. Nowadays, there are a great variety of advanced lubrication technologies includes thin film coatings [1-4], nanolubricants [5-6] and gas lubricant [7-8]. However, this study was focused on the nanolubricants. The main advantages of using nanolubricants are that they are relatively insensitive to temperature and that tribochemical reactions are limited, compared to traditional additives [9]. Most of the conventional lubricants contain a lot of additives dispersed into the oil molecule which most of its react as anti-wear agent, friction modifier, anti-corrosion and load-carrying [10]. However, some additives such as ZDDP, containing phosphorus and sulfur substance, can poison the catalytic converter which results to the failure of the emission system. Therefore, researchers and scientists are now looking for environmental friendly additives that have an ability to enhance, or at least maintain the key lubrication properties. Recently, nanoparticles are the most promising additives, where a low concentration of nanoparticles between 0.2% and 3% vol. into lubricating oil is sufficient to improve tribological properties [11-16]. Qiu et al. [15] found that the concentration of Ni nanoparticles between 0.2 and 0.5% provides the best anti-wear behavior and friction reduction. Tao et al. [16] demonstrated that 1% is considered the optimum concentration for the diamond nanoparticles in paraffin oil.

In general, as observed from prior studies, a lot of studies were investigated on the tribological properties of lubricating oil with addition of nanoparticles. However, there are a limited number of studies to investigate the oil properties of conventional diesel engine oil enriched with nanoparticles. Hence, the goal of this paper is to investigate the effect of hBN/Al_2O_3 nanoparticles dispersed in SAE 15W40 diesel engine oil on oil properties performance.

Experimental Procedure

The sonication technique was used to prepare the nano-oil by dispersing separately an optimal composition (0.5 vol.%) of hBN and Al_2O_3 nanoparticles in SAE 15W40 diesel engine oil using an ultrasonic homogenizer for 20 minutes. The particles size for both nanoparticles is 70nm. The optimal composition was determined from the previous work [5]. The hBN and Al_2O_3 nanoparticles were observed using Scanning Electron Microscopy (SEM). The oil properties were investigated in terms of Viscosity Index (VI), Total Acid Number (TAN), Total Base Number (TBN) and flash point temperature. The VI was calculated from kinematic viscosity at 40^{o}C and 100^{o}C, using a viscometer, according ASTM D2270-04 standard practice, while TAN, TBN and flash point temperature were measured using 716 DMS Methrohm machine and flash point meter, respectively.

Results and Discussion

Figure 1 shows the SEM image of hBN and Al_2O_3 nanoparticles. As shown in Figure 1(b), Al_2O_3 nanoparticles agglomerated. However, the hBN nanoparticles were well dispersed and their sizes were rather uniform.

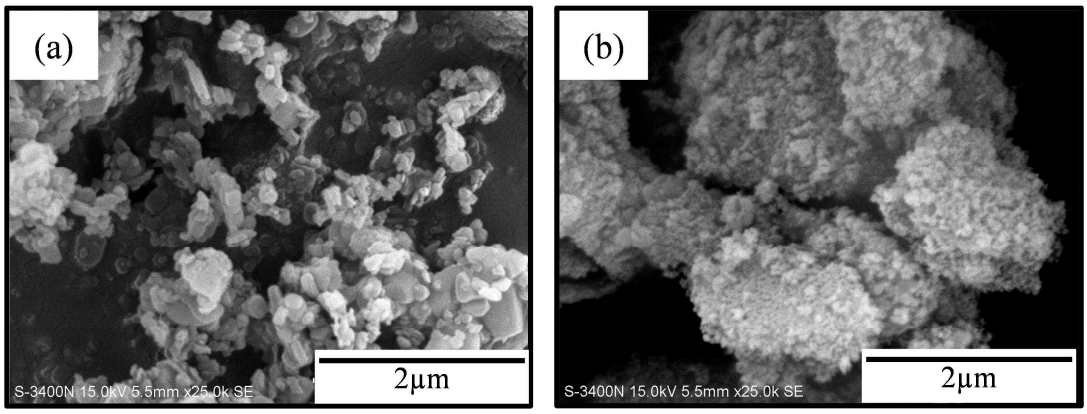

Figure 1 SEM micrograph of (a) hBN nanoparticles and (b) Al_2O_3 nanoparticles.

From Figure 2, the kinematic viscosity of nano-oil at 40^{o}C and 100^{o}C is slightly increased, as compared with conventional diesel engine oil. From the view point of boundary lubrication, these results may be due to the higher film thickness ratio.

From Figure 3, the finding provides evidence that nano-oil with hBN nanoparticles improves the VI value approximately 3%, as compared with conventional diesel engine oil and with Al_2O_3 nanoparticles additives. This circumstance may be due to lower thermal expansion coefficient of hBN nanoparticles (1 x 10^{-6}/^{o}C), so it has a good effect on thermal stability properties and directly give a significant impact on the viscosity index characterization.

As for TAN value, nano-oil showed a negative results, in which the value is increased gradually, as compared with conventional diesel engine oil. Increment approximately 20% for nano-oil with hBN nanoparticles and 27% for nano-oil with Al_2O_3 nanoparticles is not preferable because the TAN value indicates the existence of naphthenic acid corrosion problem. This corrosion might create a failure inside the engine component and can cause hazards emission to the environment.

The higher the TBN, the more effective it is in suspending wear-causing contaminants and reducing the corrosive effects of acids over an extended period of time. Therefore, the higher value of TBN could eliminate the negative effect of the TAN value.

The flash point of lubricant can be defined as lowest temperature at which it can vaporize to form an ignitable mixture in air. Although the flash point temperature of nano-oil with Al_2O_3 nanoparticles is slightly decreased, there is no significant difference in flash point temperature between the conventional diesel engine oil and with hBN nanoparticles additives.

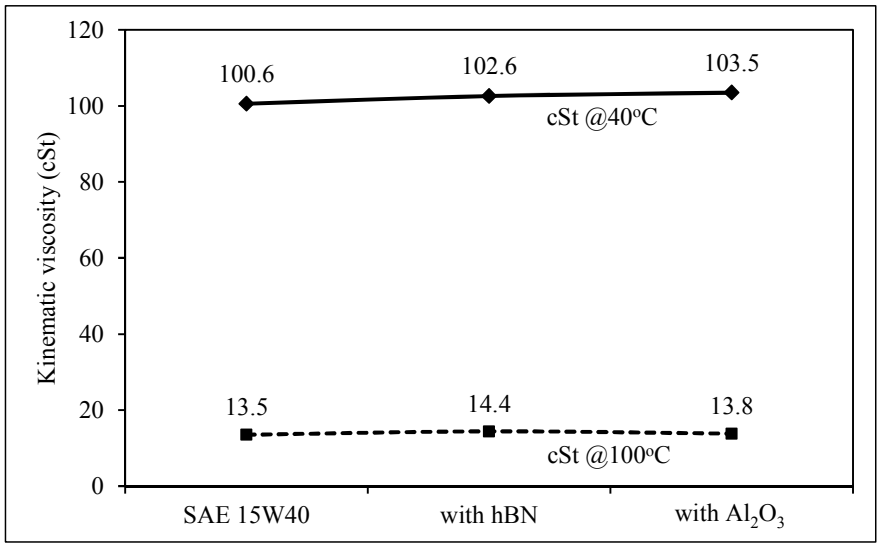

Figure 2 Kinematic viscosity measured at 40°C and 100°C.

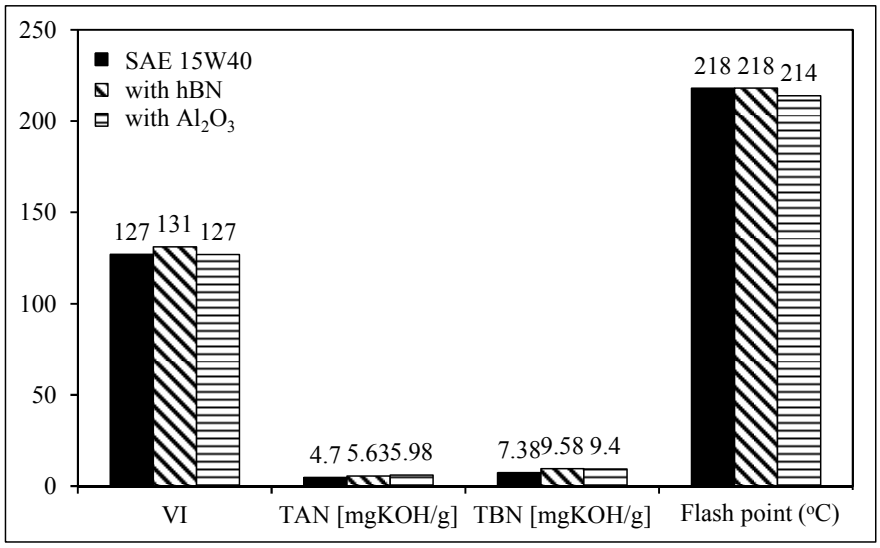

Figure 3 The oil properties comparisons between SAE 15W40, with hBN and Al_2O_3 nanoparticles.

Conclusions

This paper presented results of hBN/Al_2O_3 nanoparticles as additives for improving conventional diesel engine oil properties. In summary, as compared with conventional diesel engine oil with and without Al_2O_3 nanoparticles, the current study proves that the hBN nanoparticles dispersed in SAE 15W40 diesel engine oil could improves or at least maintain the key lubrication properties of VI, TBN and flash point temperature, though the TAN value is slightly increased. However, the higher value of TBN could eliminate the negative effect of the TAN value. Overall, this study has contributed to our knowledge about the effectiveness of hBN nanoparticles as compared with Al_2O_3 nanoparticles for improving oil properties.

Acknowledgement

The authors gratefully acknowledge contributions from the members of the Green Tribology and Engine Performance (G-TriboE) research group. This research is supported by grants from the

World Academy of Sciences (TWAS) [grant number: GLUAR/2013/FKM(2)/A00003], Ministry of Education Malaysia [grant numbers: FRGS/2013/FKM/TK01/02/1/F00163 and FRGS/2013/FTK/TK06/02/3/F00166], and Universiti Teknikal Malaysia Melaka (UTeM) [grants number: PJP/2012/FKM(40A)/S01044 and PJP/2012/FKM(11A)/S01086].

References

[1] M.F.B. Abdollah, Y. Yamaguchi, T. Akao, N. Inayoshi, M. Miyamoto, T. Tokoroyama, N. Umehara, Future developments of a deformation-wear transition map of DLC coating, Tribology Online, 3 (2012) 107-111.

[2] M.F.B. Abdollah, Y. Yamaguchi, T. Akao, N. Inayoshi, M. Miyamoto, T. Tokoroyama, N. Umehara, Deformation-wear transition map of DLC coating under cyclic impact loading, Wear, 274-275 (2012) 435-441.

[3] M.F.B. Abdollah, Y. Yamaguchi, T. Akao, N. Inayoshi, M. Miyamoto, T. Tokoroyama, N. Umehara, The effect of maximum normal impact load, absorbed energy, and contact impulse, on the impact crater volume/depth of DLC coating, Tribology Online, 6 (2011) 257–264.

[4] M.F.B. Abdollah, Y. Yamaguchi, T. Akao, N. Inayoshi, M. Miyamoto, N. Umehara, T. Tokoroyama, Phase transformation studies on the a-C coating under repetitive impact, Surface and Coatings Technology, 205 (2010) 625-631.

[5] M.I.H.C. Abdullah, M.F. Abdollah, H. Amiruddin, N. Tamaldin, N.R.M. Nuri, Optimization of tribological performance of HbN/Al_2O_3 nanoparticles as engine oil additives, Procedia Engineering, 68 (2013) 313-319.

[6] M.I.H.C. Abdullah, M.F. Abdollah, H. Amiruddin, N. Tamaldin, N.R.M. Nuri, Effect of hBN/Al_2O_3 nanoparticles additives on tribological performance of engine oil, Jurnal Teknologi (Sciences and Engineering), 66 (2014) 1-6.

[7] M.F.B. Abdollah, M.A.A. Mazlan, H. Amiruddin, N. Tamaldin, Friction behaviour of bearing material under gas lubricated conditions, Procedia Engineering, 68 (2013) 688-693.

[8] M.F.B. Abdollah, M.A.A. Mazlan, H. Amiruddin, N. Tamaldin, Experimental study on friction and wear behaviors of bearing material under gas lubricated conditions, Jurnal Teknologi (Sciences and Engineering), 66 (2014) 43-49.

[9] J.M. Martin, N. Ohmae, Nanolubricants, Wiley, England, 2008.

[10] M. Zhang, X. Wang, W. Liu, X. Fu, Performance and anti-wear mechanism of Cu nanoparticles as lubricating oil additives, Industrial Lubrication and Tribology, 61 (2009) 311-318.

[11] W. Li, S. Zheng, B. Cao, Friction and wear properties of ZrO2/SiO2 composite nanoparticles, Journal of Nanoparticle Research, 13 (2011) 2129-2137.

[12] Y.Y. Wu, W.C. Tsui, T.C. Liu, Experimental analysis of tribological properties of lubricating oils with nanoparticles additives, Wear 262 (2007) 819-825.

[13] L. Rapoport, V. Leshchinsky, M. Lvovsky, O. Nepomnyashchy, Y. Volovik, R. Tenne, Mechanism of friction of fullerenes, Industrial Lubrication and Tribology, 54 (2002) 171-176.

[14] Y. Hwang, C. Lee, Y. Choi, S. Cheong, D. Kim, K. Lee, J. Lee, S. Hyung Kim, Effect of the size and morphology of particles dispersed in nano-oil on friction performance between rotating discs, Journal of Mechanical Science and Technology, 25 (2011) 2853-2857.

[15] S. Qiu, Z. Zhou, J. Dong, G. Chen, Preparation of Ni nanoparticles and evaluation of their tribological performance as potential additives in oils, Journal of Tribology, 123 (1999) 441-443.

[16] X. Tao, Z. Jiazheng, X. Kang, The ball-bearing effect of diamond nanoparticles as an oil additive, J. Phys. D: Appl. Phys. 29 (1996) 2932.

Machine Design and Manufacturing Engineering III
10.4028/www.scientific.net/AMM.607

Improving Engine Oil Properties by Dispersion of hBN/Al_2O_3 Nanoparticles
10.4028/www.scientific.net/AMM.607.70