ISSN: 0974-5823 Vol. 6 No. 3 December, 2021

International Journal of Mechanical Engineering

CHARACTERISTICS OF GRAPHENENIO/COCONUT OIL HYBRID NANOFLUID

N. Senniangiri*
Department of Mechanical Engineering, Nandha Engineering College, Erode – 52, Tamil Nadu, India.
senniangirinatarajan1987@gmail.com

S. Magibalan
Department of Mechanical Engineering, Nandha Engineering College, Erode – 52, Tamil Nadu, India.

V.Chandramohan
Department of Mechanical Engineering, Nandha Engineering College, Erode – 52, Tamil Nadu, India.

Thangamani M
Department of Pharmacognosy, Nandha College of Pharmacy, Erode – 52, Tamil Nadu, India.

ABSTRACT

Different weight fractions of G/NiO/Coconut oil hybrid nanofluid are made using a two-step process. In a 70:30 ratio, G/NiO hybrid nanomaterials are added to Coconut oil and swirled for 3 hours using a magnetic stirrer. The samples are then sonicated for three hours to produce homogenised dispersions, and the sedimentation method is used to test their dispersion stability. The asperity interaction in the hydrodynamic, elasto-hydrodynamic, and boundary lubrication regimes is minimised when lubricants are spread with nanoparticles at varying concentrations.

Keywords: Coconut oil, lubricant, nanoparticle

1. INTRODUCTION

Lubricating compounds are used to reduce tribological issues such as friction and wear in mechanical systems. Mineral base oils are frequently used to make these (Asadi and Pourfattah 2019; Duangthongsuk et al. 2009; Li et al. 2019; Kumar and Esfe 2018). The global requirement of mineral based lubricating oil is anticipated to raise from 2.5% per year to 43.6 million metric tons in 2019, driven by the prevalent industrialization in the emergent countries of Asia and Europe. Generally, lubricating oil is utilized to generate hydrodynamic pressures, transport superfluous materials, resist oxidation and condense the friction and wear (Castillo et al. 2003; Cheng et al. 2017; Li and Ren 2017; Rajendhran et al. 2018; Wu et al. 2007). However, the disposal of lubricating agents used in industrial, automotive, marine and aerospace applications possesses numerous environmental hazards to terrestrial and aquatic ecosystems leading to the development of biodegradable lubricating agents (Kumar & Esfe 2018; Li et al. 2019; Suganthi and Rajan 2019).

Concerns about contamination and degradation of the environment have increased the need for renewable and biodegradable lubricants. Bio-lubricating agents such as edible oil have recently been discovered as a natural alternative to mineral-based lubricating oils. Bio-lubricants have a high flash point, a low fire point, and low evaporative losses. 2 Bio-lubricating agents, on the other hand, have somewhat lower lubricating qualities than mineral-based lubricating oils and have a lower oxidative stiffness (Baby and Sundara 2011; Li et al. 2019).

Li and Ren (2017) have synthesized alkylphosphate-ammonium ionic liquid additives and homogeneously dispersed into the rapeseed oil. Their outcome shows that the ionic liquid has excellent synergistic property on extreme pressure and anti-wear characteristics than the base fluid. Li et al. (2019) have synthesized MoSe2 nanomaterials using hydrothermal method and determined their tribological distinctiveness through ball-on-disk tribo-meter. They have used white oil as a base fluid. The uniform dispersion of MoSe2 nanoparticles reduces the average friction coefficient and wear rate by 43 and 87 percent, respectively, as compared to the base oil, according to their findings.

Dardan et al. (2016) have investigated the viscosities of SAE 40 lubricating oil by mono-dispersing the hybrid nanomaterials of Al2O3- MWCNT at different nanomaterial weight fractions and temperature. They have found Newtonian viscosity behavior with the viscosity enhancement of about 46%. They have proposed a new equation to estimate the viscosity of hybrid nanofluids with maximum deviation margin of 2%

In the hydrodynamic, elasto-hydrodynamic, and boundary lubrication regimes, the asperity interaction is minimised by disseminating lubricant with nanoparticles at various concentrations. To enhance the thickness of the oil layer between the steel ball contact surface under the action of contact pressure, coconut oil is ultrasonically dispersed with varying quantities of Graphene-NiO hybrid nanomaterials. The wear-resistant nature of relatively sliding surfaces under contact pressure, as well as their lubricating efficiency, is significantly affected by increasing the thickness of the interface element.

Further, the literature paper [1-16] survey based examining the chemical compositions, worn surface and the solid particles in lubricant after each Four-ball wear test is also useful for snooping the possible lubricating property enhancing mechanisms. In Four- Ball wear machine to check various load value in the 200 N to 750 N are applied on top steel ball immersed in coconut oil without any dispersed additives, 0.1 & 0.3 gram percent of G-NiO/coconut oil hybrid nanofluid, respectively

2. FORMULATION OF HYBRID NANOFLUIDS

G/NiO/Coconut oil hybrid particles with different weight fractions have been studied and coconut oil as a base fluid (Paul et al. 2011; Goharshadi et al. 2012). In the first phase of this two-step nanofluid formulation approach, the G/NiO/Coconut oil hybrid particles are introduced to Coconut oil in a 70:30 ratio and stirred for 3 hours using a magnetic stirrer[17]. The samples are sonicated individually for 3 hours (20 kHz, 1200 W, Sonics and Materials, USA) to obtain homogenised dispersions before being processed with a high-energy ultrasonicator. 0.1 & 0.3 gram percent of G/NiO/Coconut oil hybrid particles are created individually in the current work. Under addition, sedimentation approach is used to evaluate the mono-dispersion constancy of G/NiO/Coconut oil hybrid particles at various weight fractions in ambient conditions (Wei and Wang 2010). Figure 1 shows the results of a mono-dispersion stability analysis of G/NiO/Coconut oil hybrid particles using ultrasonication[18]. Up to 73 hours, the hybrid samples remain monodispersed.

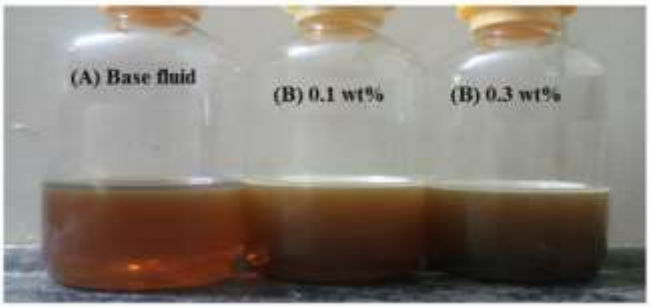

Figure 1 Graphene-NiO/coconut oil hybrid nanofluids (A) coconut oil, (B) 0.1 wt% of G/NiO/Coconut oil hybrid particles, (C) 0.3 wt% of G/NiO/Coconut oil hybrid particles

3. RESULTS AND DISCUSSION

3.1 LUBRICATING CHARACTERISTICS OF GRAPHENENIO/COCONUT OIL HYBRID NANOFLUID

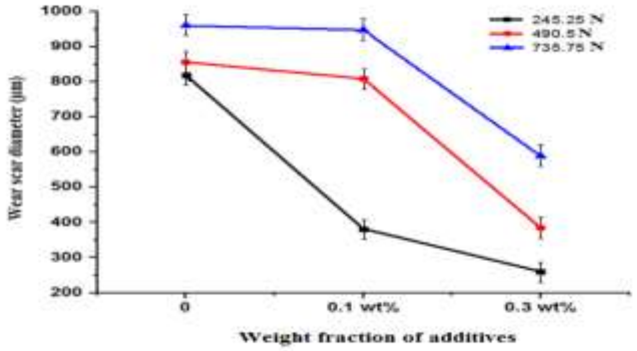

Figure 2 Wear scar diameter of contact surfaces lubricated by (a) coconut oil, (b) 0.1 wt% and (c) 0.3 wt% of Graphene-NiO/coconut oil hybrid nanofluid

Figure 2 (a) Shows that a constant speed 1200 rpm applied load at 245.25 N on the test condition first parameter is base oil wear scar diameter µm is 0.0816. Second parameter 0.1 wt% of G/NiO/Coconut oil hybrid particles wear scar diameter µm is 0.0401. Third parameter 0.3 wt% of G/NiO/Coconut oil hybrid particles wear scar diameter µm is 0.0294.

The worn surface of the lubrication of steel balls by the additive free coconut oil at 245.25 N (25 Kg) loading condition shown in (Figure 3 (A)) fully exhibits ridges separated by the furrows due to the intensive plastic deformation. The amount of plastic deformation depends on their contact pressure. However, fused contact points (welded point) are not found at this loading condition due to the existence of hydrodynamic coconut oil film. The availability of the hydrodynamic film between the contact surfaces depends on the magnitude of the applied load.

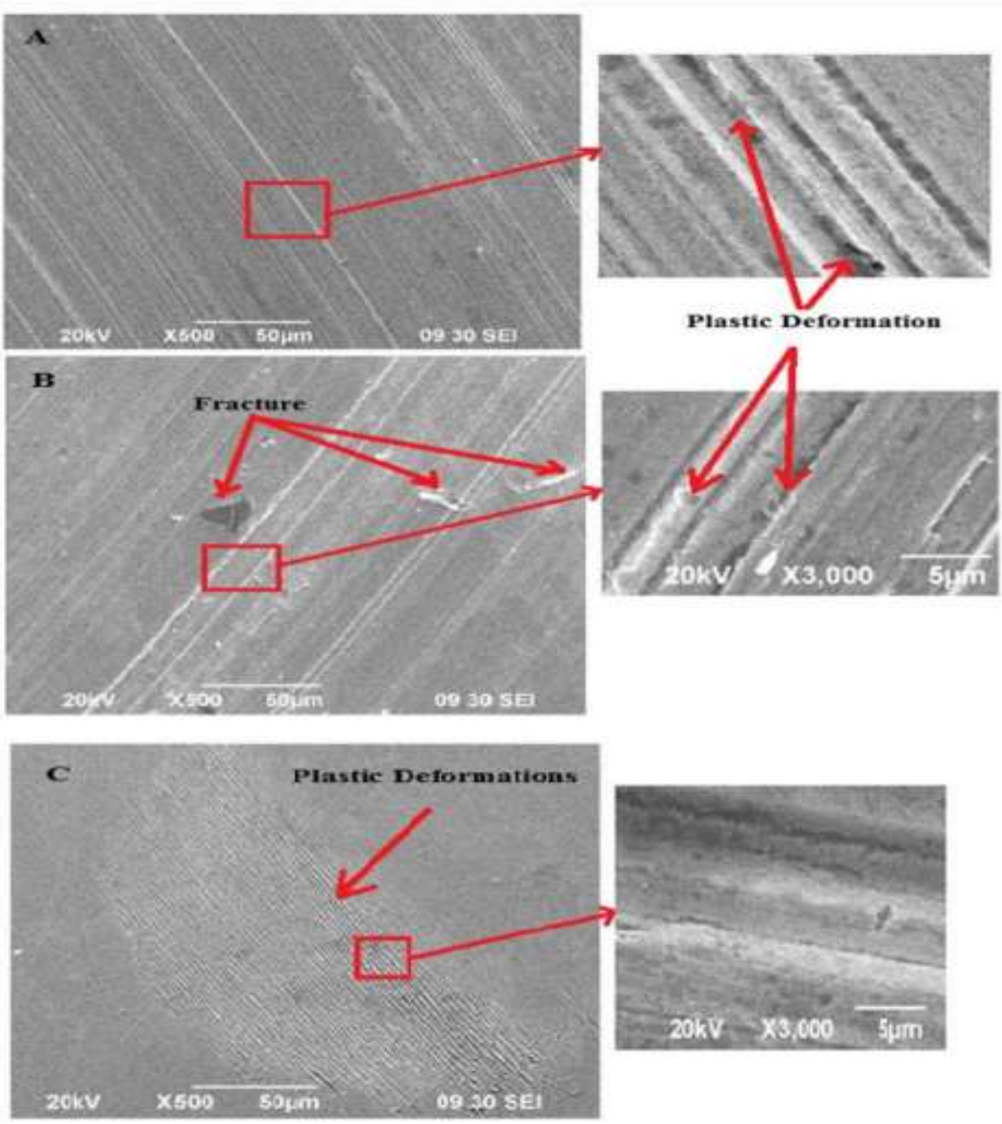

Figure 3 SEM morphology of the worn surface tested with additive free coconut oil at (A) 245.25 N, (B) 490.5 N and (C) 735.75 N loading conditions

Figure 2 (b) Shows that a constant speed 1200 rpm applied load at 490.5 N on the test condition first parameter is base oil wear scar diameter µm is 0.0854. Second parameter 0.1 wt% of G/NiO/Coconut oil hybrid particles wear scar diameter µm is 0.0823. Third parameter 0.3 wt% of G/NiO/Coconut oil hybrid particles wear scar diameter µm is 0.0498.

Figure 3 (B) depicts the worn surface of the lubrication of steel balls by the additive free coconut oil at 490.5 N (50 Kg) loading condition. It is observed that large amounts of metal parts are fused and welded together. It indicates that the thickness of the coconut oil film fails to make the contact surfaces to float which creates plastic deformation on the rubbing interface. However, this resistance to relative motion between the steel ball contact surfaces is less than that of dry surface motion.

Figure 2 (c) Shows that a constant speed 1200 rpm applied load at 735.75 N on the test condition first parameter is base oil wear scar diameter µm is 0.1008. Second parameter 0.1 wt% of G/NiO/Coconut oil hybrid particles wear scar diameter µm is 0.0975. Third parameter 0.3 wt% of G/NiO/Coconut oil hybrid particles wear scar diameter µm is 0.0693.

Figure 3 (C) depicts the worn surface of the lubrication of steel balls by the additive free coconut oil at 735.75 N (75 Kg) loading condition. During this intensive loading condition also, the coconut oil completely fails to make the contact surfaces of the steel balls to float which creates severe plastic deformation and many weld points on the rubbing interface.

4. Conclusion

1. The wear scar width for pure coconut oil is higher than for various weight fractions of G/NiO/Coconut oil hybrid nanofluid has been lubricating properties.
2. The worn surface of the steel balls lubricated by 0.3 wt percent G/NiO/Coconut oil hybrid nanofluids displays no visible ridges or furrows at 245.25 N loading conditions.
3. Steel ball contact surfaces are separated by a totally hydrodynamic layer that allows them to float or glide.

4. Boundary lubrication occurs, the uniformly dispersed nanomaterials in the steel ball contact surfaces function as a third body that divides the contact surfaces.
5. The lubricant's nanoparticles may roll between the steel balls' contact surfaces during this boundary lubrication, transforming the sliding friction of the contact surface to rolling friction.

5. References

1. Asadi, A & Pourfattah, F 2019 „Heat transfer performance of two oilbased nanofluids containing ZnO and MgO nanoparticles; a comparative experimental investigation", Powder technology, vol. 343, pp. 296-308.
2. Baby, T, Theres & Ramaprabhu, S 2011 „Experimental investigation of the thermal transport properties of a carbon nanohybrid dispersed nanofluid", Nanoscale, vol 3, no 5, pp 2208-2214. 10.
3. Baby, TT & Sundara, R 2011 „Synthesis and Transport Properties of Metal Oxide Decorated Graphene Dispersed Nanofluids", The Journal of Physical Chemistry C, vol. 115, pp. 8527-8533.
4. Castillo F & Spikes H 2003 „Mechanism of action of colloidal solid dispersions", Journal of Tribology, vol 125, pp 552-557.
5. Cheng, L, Li, W & Liu, Z 2017 „Preparation, characterization, and tribological properties of oleic diethanolamide-capped zinc boratecoated graphene oxide composites", Journal of Alloys and Compounds, vol. 705, pp. 384-391.
6. Dardan, E, Afrand, M & Isfahani, AM 2016 „Effect of suspending hybrid nanoadditives on rheological behavior of engine oil and pumping power", Applied Thermal Engineering, vol 109, pp 524-534.
7. Duangthongsuk, W & Wongwises, S 2009 „Measurement of temperature-dependent thermal conductivity and viscosity of TiO2-water nanofluids", Experimental Thermal and Fluid Science, vol. 33, pp. 706-714.
8. Kumar, RS & Esfe, MH 2018 „Stability and rheological properties of nanofluids stabilized by SiO2 nanoparticles and SiO2-TiO2 nanocomposites for oil field applications", Colloids and Surfaces A: Physicochemical and Engineering Aspects, vol. 539, pp. 171-183.
9. Kumar, V & Sarkar, J 2019 „Numerical and experimental investigations on heat transfer and pressure drop characteristics of Al2O3-TiO2 hybrid nanofluid in minichannel heat sink with different mixture ratio", Powder technology, vol 345, pp 717-727.
10. Li, F, Li, L, Zhong, G, Zhai, Y & Li, Z 2019 „Effects of ultrasonic time, size of aggregates and temperature on the stability and viscosity of Cu-ethylene glycol (EG) nanofluids", International Journal of Heat and Mass Transfer, vol.129, pp. 278-286.
11. Li, Y, Lu, H, Liu, Q, Qin, L & Dong, G 2019 „A facile method to enhance the tribological performances of MoSe2 nanoparticles as oil additives", Tribology International, vol 137, pp 22-29.
12. Li, Z & Ren, T 2017 „Synergistic effects between alkylphosphateammonium ionic liquid and alkylphenylborate as lubricant additives in rapeseed oil", Tribology International, vol 109, pp 373-381.
13. Rajendhran, N, Palanisamy, S, Periyasamy, P & Venkatachalam, R 2018 „Enhancing of the tribological characteristics of the lubricant oils using Ni-promoted MoS2 nanosheets as nano-additives", Tribology International, vol. 118, pp. 314-328.
14. Suganthi, KS & Rajan, KS 2017 „Metal oxide nanofluids: Review of formulation, thermo-physical properties, mechanisms, and heat transfer performance", Renewable and Sustainable Energy Reviews, vol 76, pp. 226-255.
15. Wei, X & Wang, L 2010 „Synthesis and thermal conductivity of microfluidic copper nanofluids", Particuology, vol 8, no 3, pp. 262-271.
16. Magibalan, S., 2020. Mechanical Properties of the Palmyra Fibre Epoxy Composites. In Green Materials and Advanced Manufacturing Technology, pp. 67-74
17. Muthukumar M., Karthikeyan P., Vairavel M., Loganathan C., Praveenkumar S., Senthil Kumar A.P., "Numerical studies on PEM fuel cell with different landing to channel width of flow channel", Procedia Engineering, Volume 97, Pages 1534-1542, December 2014
18. Karthikeyan, M., Karthikeyan, P., Muthukumar, M., Magesh Kannan, V., Thanarajan, K., Maiyalagan, T., Chae-Won Hong, Jothi, V.R., Sung-ChulYi., "Adoption of novel porous inserts in the flow channel of pem fuel cell for the mitigation of cathodic flooding", International Journal of Hydrogen Energy, Volume 45, Issue 13, Pages 7863-7872, 2020