Effect of nanoparticles morphology on the viscosity of Nano lubricants

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Abstract

In present study, heavy machine lubricating oil based nanolubricants has been prepared by the dispersion of Al_2O_3 and CeO_2 nanoparticles. The viscosity of the samples has been measured at varying nanoparticles in volume fraction range of 0.1%-0.4%. The same volume fraction of Al_2O_3 and CeO_2 nanoparticles produced varying modification in viscosity. Further existing mathematical models has been used to identify the deviation in predicted values of viscosity. Existing mathematical model found inappropriate for the viscosity prediction of gear oil nanolubricant and new correlation proposed for it.

Keywords

Al_2O_3; CeO_2; Nanolubricant; Mining; Viscosity

Nomenclature

Symbol	Represent	Symbol	Represent
ϕ	Particle volume fraction (vf)	d_p	Diameter of particle
μ	Viscosity	d_{bf}	Diameter of base fluid
ρ	Density	M	Molar Mass
nf	Nanofluid	N	Avogadro Number
bf	Base fluid		

1. Introduction

These high horsepower engine require improved lubricant, which ensure optimal running of engine equipment for its expected useful life cycle. Frictional energy in mineral mining consumes 40% of the available energy [1]. Nanolubricants, base oil with dispersed nanoparticles (nps) additives, provide a new scope for improvement in machine lubrication [2]. The dispersion of nps in base lubricant, modify its viscosity and other thermophysical properties. Ali et al. [3] observed there was decrement in the viscosity of SAE5W30 with the use of Al_2O_3/TiO_2 hybrid nps additive. Asadi et al. [4] found 25% increment in viscosity with 2% MWCNT/SiO_2 nps in SAE 30 engine oil. Kotia et al. [5] used 1.5% vf of Al_2O_3 nps in mining SAE 68 and observed viscosity increment of 15%. Kariyar et al [6] tested the viscosity of Fe-Ni paraffin oil nanolubricant using 10% weight concentration of nanoparticles. Murshed et al. [7] observed viscosity enhancement for ethylene glycol based nanolubricant using TiO_2 and Al_2O_3 nanoparticles as additives. Kole

		≤0.7405
$\mu_{nf} = \mu_{bf} \times 13.47 e^{35.98\phi}$	**[22]**	TiO_2/ water mixture
$\boldsymbol{\mu_{nf} = \mu_{bf}(1 + 12.8\emptyset + (32\emptyset)^2)}$	**[24]**	Al_2O_3 gear oil nanolubricant

In present study, machinery lubricating oil based nanolubricants has been prepared by the dispersion of Al_2O_3 and CeO_2 nanoparticles in the volume fraction range of 0.1-0.4%. Viscosity of the samples is measured using Stabinger viscosmeter. Existing correlations has been used to estimate the viscosity of nanolubricants.

2. Material and Measurement

The nanolubricant samples have been prepared by the dispersion of nanoparticles in 0.1%-0.4% particle volume fraction in gear oil. Accurate measurement of the weight of nanoparticles required for each sample is calculated using equation (1) [23]. The samples are made homogeneous using 1 hour of magnetic stirring at 500 rpm. Further to break the agglomeration of nanoparticles in the samples, samples are put for intensive ultrasonification (20kHz) in a probe sonicator for 1 hour. Figure 1 shows the aging test for nanolubricant samples. In this samples are kept for still stand for six weeks and the viscosity of the samples is monitor at regular time intervals. It has been observed that there is only minor change in viscosity with time, which indicates the samples are stable in test duration.

$$\phi = \frac{\left(\frac{w_{np}}{\rho_{np}}\right)}{\left(\frac{w_{np}}{\rho_{np}}\right) + \left(\frac{w_{bf}}{\rho_{bf}}\right)} \quad (1)$$

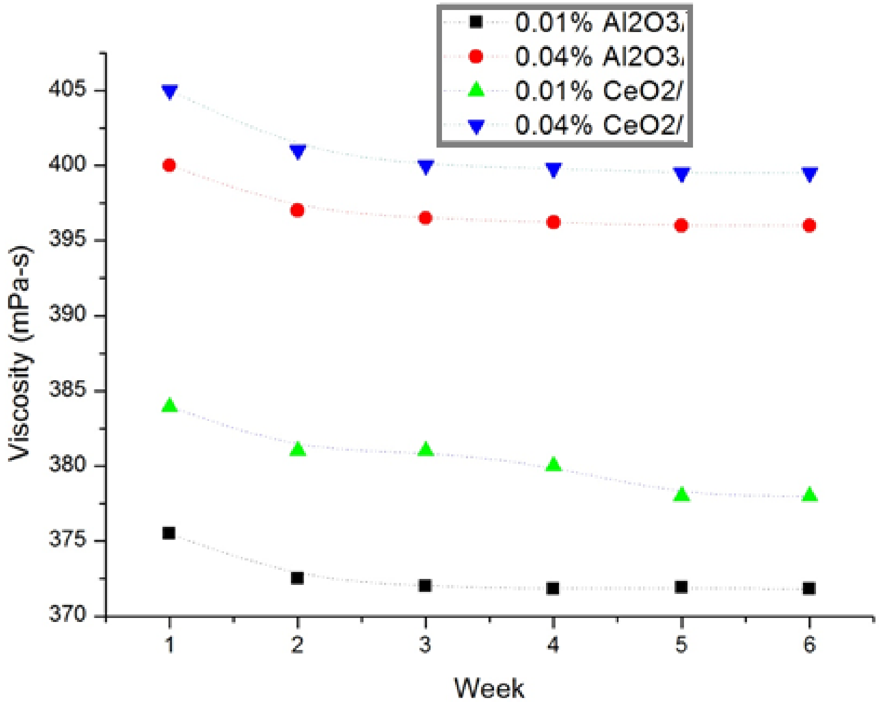

Figure 1: Aging test for nanolubricant samples

The viscosity of the samples has been measured by using Stabinger Viscometer (Aton Paar, SVM 3000), which work on Couette principle. The viscosity of the samples is measured at 20 ^oC temperature and normal atmospheric pressure.

3. Results & discussion

It can be observed that at same particle vf Al_2O_3 based nanolubricant have lesser increment in viscosity compared to CeO_2 based nanolubricant. There was 1.48% increment in viscosity is observed in Al_2O_3 based nanolubricant with 0.1% particle vf, whereas for same vf 3.77% increment in viscosity is observed in CeO_2 based nanolubricant. The spherical Al_2O_3 nanoparticles produced ball bearing effect, which reduce viscous friction in adjacent fluid layers.

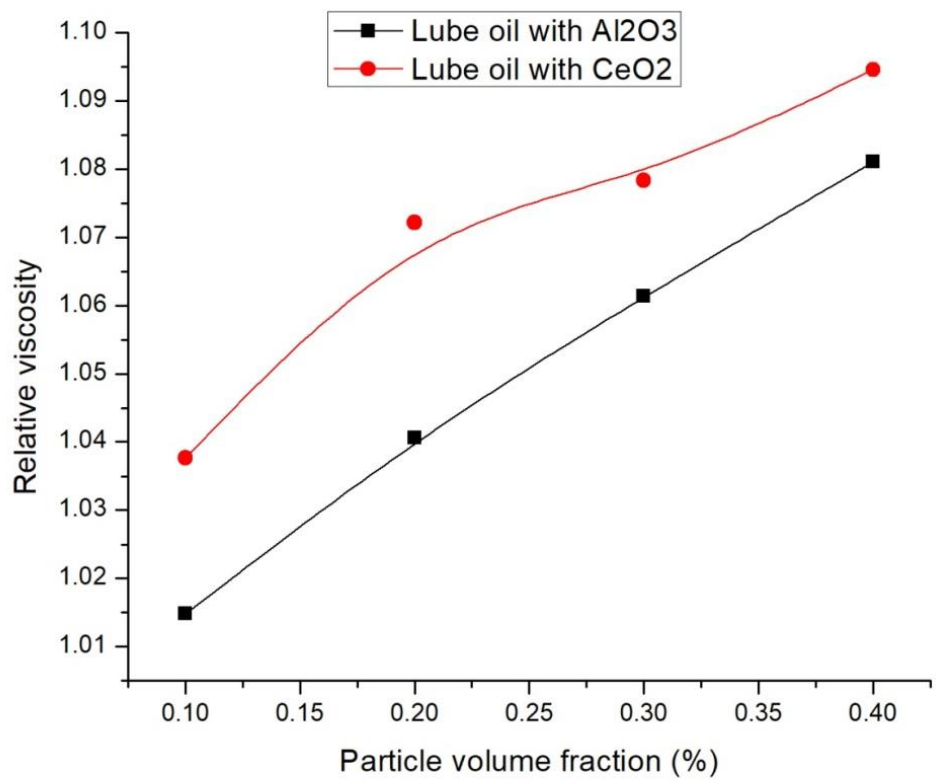

Figure 2: Comparison on variation in viscosity at same particle volume fraction

Figure 3 variation for Al_2O_3 based nanolubricant with varying nanoparticles vf. It has observed that dynamic viscosity almost linearly increases with the increase in Al_2O_3 particle vf.

Figure 4 variation CeO_2 based nanolubricant with varying particle vf. It can be observed that dynamic viscosity non-linearly increases with CeO_2 particle vf.

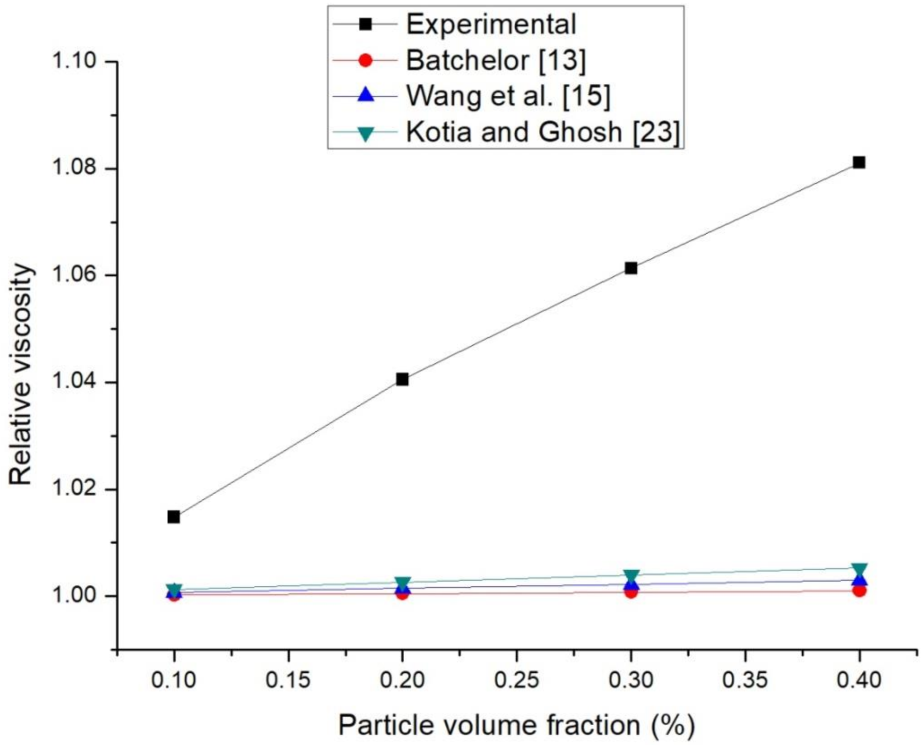

Figure 3: Variation of relative viscosity for Al_2O_3 based nanolubricant

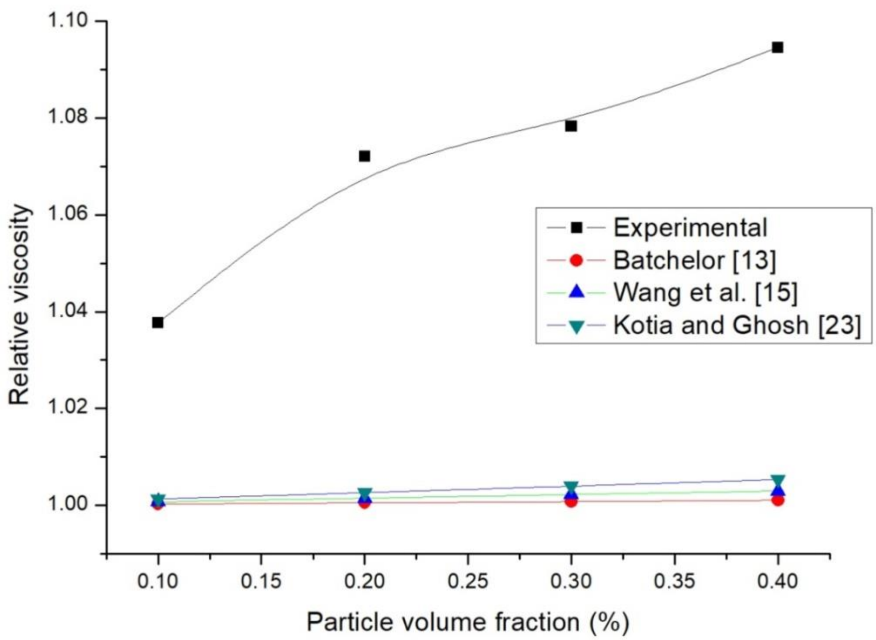

Figure 5: Variation of relative dynamic viscosity for CeO_2 based nanolubricant

4. Conclusion

In present study, the effect of the nanoparticles morphology on the viscosity machine lubricating oil based nanolubricants has been analyzed. The nanolubricant samples were prepared by the dispersion of Al_2O_3 and CeO_2 nanoparticles in 0.1% - 0.4% particle volume fraction. Aging test shows nanolubricants sample are stable in test duration. The viscosity variation Al_2O_3 based nanolubricant was linear, whereas non-liner variation is observed in CeO_2 based nanolubricants. The existing conventional models found inappropriate in viscosity predication, hence new models has been proposed for viscosity variation in nanolubricant samples.

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