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TECHNICAL PAPER

Experimental study on rheological properties of vegetable oils mixed with titanium dioxide nanoparticles

Wani Khalid Shafi[1] · M. S. Charoo[1]

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Abstract

The paper focuses on studying the rheological properties of different vegetable oils mixed with TiO_2 nanoparticles. The rheological tests of vegetable oils are conducted on cone and plate geometry of Anton Paars rheometer (MCR-102). TiO_2 nanoparticles are added in 0.5 wt%, 1 wt% and 1.5 wt% concentration. The density of nanofluids is measured from 20–80 °C, and the viscosity of nanofluids is measured at temperatures of 40 °C, 70 °C and 100 °C. All the nanofluids depict Newtonian behaviour at different temperatures and are quantified by power law. The introduction of nanoparticles in the oils leads to the increase in viscosity with 1.5 wt% TiO_2 concentration displaying maximum increase in viscosity in all the bio-oils. The variation of viscosity with temperature, shear rate and particle volume fraction is observed, and the measured values of viscosity are correlated with the existing theoretical viscosity models.

Keywords Sustainable lubrication · Vegetable oils · Titanium dioxide · Nanoparticles

List of symbols

U	Experimental viscosity (mm^2/s) at 40 °C
Y	Experimental viscosity (mm^2/s) at 100 °C
ϕ	Solid volume fraction
W_n	Weight percentage of nanoparticles (g)
W_o	Weight of base oil (ml)
ρ_n	Density of nanoparticles
ρ_o	Density of oil
τ	Shear stress (Pa)
γ	Shear strain (1/s)
k	Consistency index
n	Power law index
η_r	Relative viscosity of fluid
μ_{nf}	Dynamic viscosity of nanofluid
μ_{bf}	Dynamic viscosity of base fluid

1 Introduction

Global warming and other ecological degradations by the release of harmful, toxic gases from mineral oils is a chief concern in today's era. It has made the use of biodegradable resources inevitable. One emerging solution to the ecological degradation is biolubrication [1]. Biolubricants are gaining importance in the field of sustainability owing to their properties of biodegradability and sustainability. Biolubricants include plant-derived oils and animal fats. Vegetable oils possess all the necessary qualities of a conventional lubricant like high fire point, better viscosity index, high flash point and superior biodegradability [2]. Various tribological investigations have been carried out on vegetable oils and its effectiveness as lubricant has been evaluated. Jayadas and Nair [3] evaluated low temperature, thermal and oxidative properties of coconut oil, sesame oil and sunflower oil. It is observed that the coconut oil exhibit better oxidative and low temperature properties as compared to the sunflower and sesame oil. High oxidation stability of the coconut oil is attributed to the presence of high content of saturated fatty acids. Fox and Stachowiak [4] investigated the performance of sunflower oil in boundary lubricating conditions and reported that the presence of unsaturated fatty acids decreases the performance of sunflower oil. Double bonds are the active sites for oxidation resulting in the thermal degradation of the oil. Consequently, the oils with high

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✉ M. S. Charoo
shaficharoo123@nitsri.net

[1] National Institute of Technology, Hazratbal, Srinagar 190006, India