Performance evaluation of hazelnut oil with copper nanoparticles - a new entrant for sustainable lubrication

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Abstract

Purpose – This paper aims to investigate the friction and wear performance of Hazelnut oil with copper (Cu) nano additives.

Design/methodology/approach – The experiments were performed on a pin-on-disc tribometer in boundary and mixed lubrication regimes. Copper nanoparticles were added in 0.5 and 1 Wt.% concentrations and corresponding Stribeck curves were generated with a base oil and with oil containing Cu nanoparticles. Surface analysis of aluminium 6061 pins was conducted using an optical microscope, scanning electron microscope and energy dispersive spectroscopy.

Findings – The lubricant with 0.5 Wt.% Cu nanoparticles exhibited better results. An improvement of around 80 per cent in coefficient of friction and around 99 per cent in specific wear rate was observed. The film formation capability of the Cu nanoparticles led to an overall improvement in tribological properties of the base oil.

Originality – Experiments were performed to evaluate the tribological performance of a new lubricant (Hazelnut oil) using Cu nanoparticles. The results obtained herein suggest that Hazelnut oil has a great potential to replace the conventional mineral oils in the field of industrial lubrication.

Keywords Hazelnut oil, Copper nanoparticles, Nano-lubrication

Paper type Research paper

Nomenclature

SEM = Scanning Electron Microscope;
EDS = Energy Dispersive Spectroscopy;
COF = Coefficient of Friction;
PAO = Polyalphaolefin;
Cu = Copper;
RPM = Revolutions Per Minute;
k = Ellipticity Parameter;
R = Composite Radius (m);
η = Absolute Viscosity (Pa *s*);
u = Sliding Velocity (m/s);
L = Load (N);
E = Composite Elasticity Parameter (GPa);
d = Wear Scar Diameter (m);
r = Pin End Radius (m);
D = Sliding Distance (m);
V = Volume Loss (mm3);
W_{sp} = Specific Wear Rate (mm3/N-m);
λ = Specific Film Thickness;
h_{min} = Minimum Film Thickness (nm);
R_p = Surface Roughness of Pin (μm); and
R_d = Surface Roughness of Disc (μm).

1. Introduction

The growing environmental concerns and continuous increase in energy requirement has motivated the researchers to work towards sustainable solutions (Anand *et al.*, 2017). The non-biodegradability associated with mineral oils poses serious environmental concerns. Stringent environmental regulations and awareness among the end users has forced the industry to search for eco-friendly and renewable lubricants. Vegetable oils are emerging as appropriate candidates as substitutes to mineral oils because of their excellent properties such as high fire points, high flashpoints, high viscosity index, high corrosion resistance and excellent biodegradability (Salimon *et al.*, 2010). Different research studies have investigated the tribological properties of various vegetable oils such as soyabean oil, sunflower oil, castor oil, cotton oil, *Jatropha* oil and palm (Adhvaryu and Erhan, 2002; Fox *et al.*, 2004; dos Santos Politi *et al.*, 2013; Shahabuddin *et al.*, 2013; Masjuki *et al.*, 1999). Masjuki *et al.* (1999) carried out a comparative tribological research of palm and mineral oils. The experiments revealed that the palm oil outperformed mineral oil in terms of the anti-wear property, whereas mineral oil exhibited good results w.r.t anti friction property. Cermak *et al.* (2013) studied the properties of different vegetable oils, namely, pennycress, meadow form, *cuphea* and *lesquerella*. Each vegetable oil exhibited unique properties, such as high viscosity index, high flash and fire points, low pour points and excellent

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