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Investigation of the Viscoelastic and Thermo-physical Properties of Mineral Base Engine Oils Containing Multi Walled Carbon Nanotubes

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Abstract

It is a known fact now that the commercially available lubricating oils depict lower thermo-physical features when compared with lube oils with antiwar additives. **Objective:** The thermo-physical and viscoelastic properties such as shear rate, shear stress, viscosity, Torque and ultrasonic velocity of additivated mineral base engine oils were calculated and studied for improvement markers. **Method:** In the current experimental work, samples were prepared for two different mineral base engine oils of 20W50 grade with one sample each of base fluid and three each with multi walled carbon nanotubes coated with stearic acid (carboxylic acid) added in 0.1 %, 0.3% and 0.5% wt concentration to base sample respectively. The Multi walled carbon nano tubes (MWCNTs) were then dispersed in a mineral oil by ultrasonication. The properties were investigated using a Rheometer (viscoelastic properties), ultrasonic velocity measurements were conducted using nano fluid interferometer and thermal conductivity was recorded using KD2 pro thermal property analyser apparatus. A comparative analysis is given in this paper. **Findings:** The results show that by functionalization of MWCNTs, the viscoelastic properties of the base mineral oil improved as more stable bonds were created on metallic surface due to improved absorption qualities. It was also deduced that due to coating of MWCNTs with carboxylic group stearic acid, the stability of suspension is high and it does not coagulate. **Applications:** The applications and benefits are numerous including automobile sector, heavy machinery sector etc.

Keywords: Engine Oil Lubricants, Thermo-physical Behaviour, Ultrasonic Velocity, Viscoelasticity

1. Introduction

It has been established that commonly available lubricating oils depict lower thermo-physical features when equated lube oils with antiwar additives. It has also been probed that their effectiveness can be improved by addition of nano- particles and such additivated lube oils have unlimited prospective to meet out the general lube oil and heat dissipation needs of any particular machine or mechanism. The fundamentals of nanofluid study were discussed by Choi and associates by effectively diffusing nano-particles of greater thermal conductivity in to the working specimen fluids[1].

Nano technology can be safely presumed as most important research area of current century. Its applications range from communication, electronics, power production, information technology, bio-medical engineering, material science, etc[2]. New developments are taking place

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in this area with each passing day. For refrigeration and air conditioning purposes the heat dissipating functions can be improved to cool down most active parts of compressor, taking the inside frictional heat away to the outside of machine or the oil cooler[3].

Nanofluids[4] are a type of re-engineering elements containing particles in nanometer range which are then dispersed in lube base fluids. To investigate the thermo-physical properties of nano fluids, thermal conductivity and kinematic viscosity were measured[5]. Thermo-physical characteristics[6-10] of nano fluid tends to improve with growing percentage concentration of additives barring water-based fullerene nanofluid which depict poor erthermo-physical properties than the basic lube oil fluidic sample[11].

In our paper we report preliminary results on viscoelastic and thermo-physical properties and ultrasonic velocity of MWCNTs in a blend with two different mineral engine oils. The objective of this work is to study the consequences of fictionalization of MWCNTs with stearic acid (carboxylic group) coating, on its antiwar properties, as well as on steadiness of the suspension.

2. Experimental work

The experimental study is primarily focused on preparing samples by dispersing carboxylic group stearic acid coated MWCNTs in different concentrations (0%, 0.1%, 0.3% and 0.5%) in two mineral base engine oils and testing them for viscoelastic properties, thermo-physical properties and ultrasonic viscosity.

Before using them in experimentation, the base fluid was prepared by dispersing functionalised MWCNTs in 0, 0.1, 0.3 and 0.5 wt. % using ultra sonication technique. The stability of the suspension was established when particles did not coagulate.

It was found that their diffusion in mineral base oil is advantageous because it reduces the friction coefficient and wear rate when compared to the results observed for non additivated base oil. We effectively enhanced the stability of suspension by using MWCNTs as friction modifier additives.

MWCNTs are helping to the decrease of the friction, being possible friction reducing additives for mineral base engine oils.

2.1 Materials

The required synthesised MWCNTs were supplied by Reinste Nano ventures, Gurgaon, Haryana, India as per the following specifications as given in Table 1.

The mineral base engine oil was purchased from Dhawan Lubricants, Chandigarh, and Punjab, India. The samples as shown in Figure 1 were prepared as per experimental requirement.

3. Results and Discussion

We selected two mineral based engine oils JRT3 and JRT4(both 20W50 grade) and prepared four samples each by dispersing functionalized MWCNTs in 0%, 0.1%, 0.3% and 0.5% concentration. Viscoelastic properties such as shear rate, shear stress, viscosity, Torque, ultrasonic velocity and thermal conductivity of additivated mineral base engine oils. The properties were investigated using a Rheometer (viscoelastic properties), ultrasonic velocity measurements were conducted using nano fluid interferometer and thermal conductivity was recorded using KD2 pro thermal property analyser apparatus.

The viscoelastic propertiesover a range of varying temperature were recorded using a Rheometer MCR302 apparatus, SN000000, ID 80963516 from Anton Paar Gurgaon. Measuring system PP25/PE-SN25125 (d = 0.4 mm) with accessory TUI = P-PTD200-SN 81183777.

The setup is used to measure the shear stress (σ), viscosity (η), and torque (τ) for all four samples as a function

Table 1. Specifications of MWCNTs

Purity	> 95wt%
Thickness	1.0–1.77nm
Diameter:	10–50um:
Layers	1–5
SSA(Specific surface area)	360–450m2/g
Appearance	black powder

Figure 1. Mineral base engine oil samples concentrated with 0, 0.1, 0.3 and 0.5 wt % of functionalized MWCNTs.

of temperature in a range from 30^0 C to 80^0 C at constant shear rate (γ) of 10sec^{-1}. 20 data points were selected with measuring duration of 720 seconds. Shear stress, viscosity, and shear rate are related to the following relation $\sigma = \eta\gamma$. The measured values of shear stress, viscosity, and torque with temperature are reported in Figures 2–4.

The graph shows that as the concentation is increased to 0.5%, the properties get enhanced substancially as shown in Figure 5. Further the thermo-physical behavior of the fluids under study is discussed.

From the graphs it is quite evident that with the quantity of CNTs, the thermal conductivity of the solution also increases. The variation of ultrasonic velocity with increasing concentrations of MWCNTs is shown in Figure 6.

It is quite evident from the relation among ultrasonic velocity and concentration of MWCNTs, that there is improvement in ultrasonic velocity of lubricant with increasing concentrations.

4. Conclusions

The conclusions can be drawn as follows.

a.) The viscoelastic parameters, thermal conductivity and ultrasonic velocity all show positive improvement with increase in concentration of nanotubes.

b.) For 0.5% additives dynamic viscosity, shear stress and torque show improvement of 5%, 4% and 4% respectively after running time of 720 seconds and attaining general engine oil running temperature of 80°C.

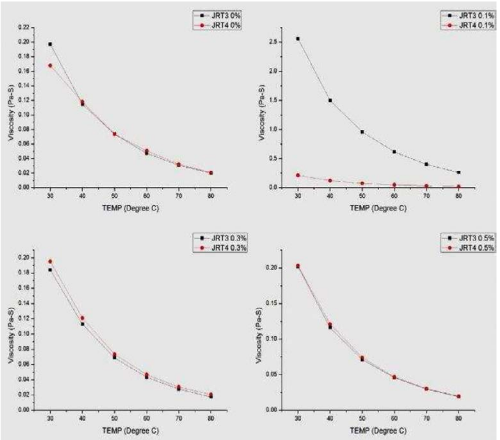

Figure 2. Showing the variation of dynamic viscosity of JRT3 and JRT4 for 0%, 0.1%, 0.3% and 0.5% MWCNTs concentration samples over a Temperature range of 30° C - 80° C.

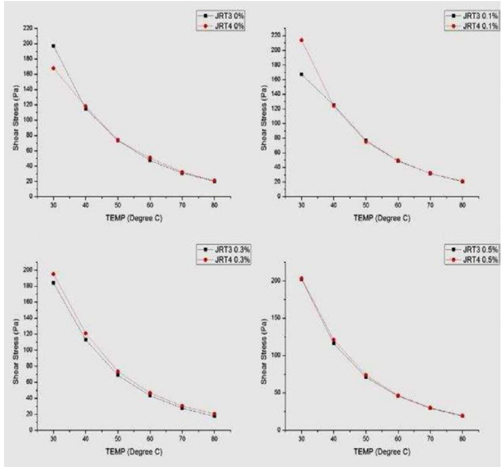

Figure 3. Showing the variation of Shear Stress of JRT3 and JRT4 for 0%, 0.1%, 0.3% and 0.5% MWCNTs concentration samples over a Temperature range of 30°C - 80° C.

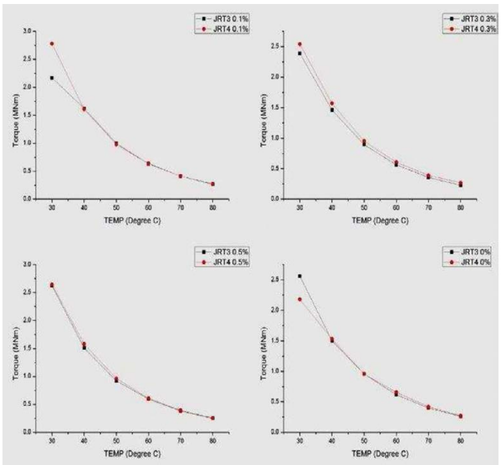

Figure 4. Showing the variation of Torque of JRT3 and JRT4 for 0%, 0.1%, 0.3% and 0.5% MWCNTs concentration samples over a Temperature range of 30° C - 80° C.

c.) By increasing concentration of mwcnts in 0.1, 0.3 and 0.5 wt %, thermal conductivity showed a gradual increase of about 4.5%, 6.5% and 8% respectively.

d.) Sound velocity was attained for all the samples. The evaluation of outputs explained the dependency on temperature variation. The alternatives to pure engine oils can be proposed using the results.

e.) For 0.5% additives ultrasonic velocity show improvement of 2% and 3% respectively for JRT3 and JRT4.

It is thus highly recommended to use friction modifiers or wear reducing additives to make them more efficient in terms of improvement in thermal conductivity and viscoelastic properties.

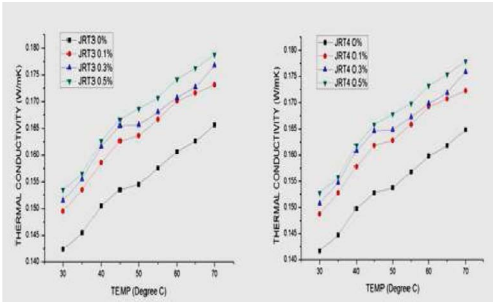

Figure 5. Thermal conductivity of JRT3 and JRT4 for different concentrations of functionalised MWCNTs.

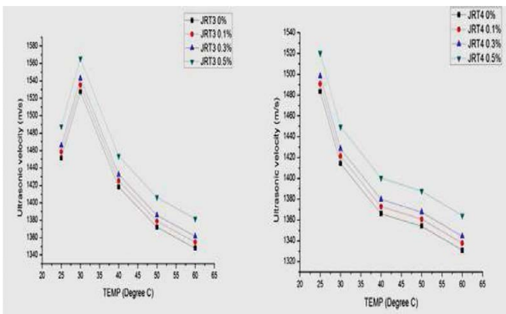

Figure 6. Ultrasonic velocity variation of JRT3 for different concentrations of functionalised MWCNTs.

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