Rheological Analysis on Kusum Oil for Sustainable Bolubricant in Electric Vehicle Application

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Abstract: Due to the depletion of fossil fuels the prices are increasing sky high and also the pollutants produced from fossil fuels are becoming challenging day by day. Researchers presently focused on bio fuels and bio lubricants to reduce dependence ofon fossil. The present study analyzes rheological properties of Kusum oil to provide an alternative lubricant for electric vehicle. The oil samples are tested in plain and with MWCNT and Cerium oxide (CeO2) nanoparticles. It was observed MWCNT and CeO2 made 12% and 10% improvement in viscosity at lower shear rate respectively, however no significant change was observed at higher shear rate. The dispersion of nanoparticles provides reduction in shear thinning behavior and hence improving the lubrication properties.

1. Introduction

Bio lubricants are more advantageous than mineral oil-based lubricants because it has a higher flash point, higher boiling point, high lubricity, high biodegradability, high Viscosity index, low volatility and less toxic [1]. Since these fossil fuels are Non Renewable and the extraction process of coal, oil and gas could be dangerous and indeed polluting. Burning of these conventional fuels cause lot of pollution by releasing green house gases including carbon monoxide and carbon dioxide. This could be either by heating or by burning of fuel in Automobiles. They contain high amount of carbon which when released to atmosphere cause Global warming and has huge impact on Air Quality Index. On the other side, there are limited amount of fossil fuels available and reserves are not replenished naturally. They are going to deplete one day completely and its our duty to make the way for possible Alternative that can successfully replace these fuels [2]. It take million of years to Naturally process it, while the consumption rate is way high due to gradual increase in population. These fuels are Even not environmental friendly. Serious health issues...
are related to this to these burning of conventional fuels. A Report from WHO shows 7 million premature deaths are actually linked to Air pollution [3]. It means millions of children killed every year by pollution. Marine life is also impacted badly when released from industries and factories in the form of waste lubricant. Some toxic substances have adverse effect on the health of aquatic life and as a result to human life also. To ensure the best possible protection; production, application and disposal has to be set in such away that it has minimum effect on environment. And above all that, Rising prices of these fuels due to market fluctuateions is also major concern. It happens because of middle east countries holding the rope of 40% of total oil production. For the long time, oil has been used as a lubricant in automobile and mechanical world [4]. According to the research, 46 millions killolitres/year of lubricant is used in the world in 2008 and there is a increase of 2% with every passing year. Approx 1% of total mineral oil consumption is used in making of lubricants. As a engineer we need to make efforts in the field of science of technology to find the alternative [5].

1.1 Biolubricant and their properties.

Biolubricant can be defined as the lubricant we get from Natural raw materials like vegetable and animal oils which are non toxic to human life as well as are Ecofriendly. Chemical modifications like transesterification, esterification is done to get the desired product. Vegetable oil can be edible or Non edible but it has lubrication characteristics. Castor oil, rapeseed oil, palm seed oil, thumba oil, tamanu oil and linseed oil potential candidates for biolubricants. In general, biolubricants display good tribological, viscosity index and high flash point [6]. Lower volatility of these lubricants have lower exhaust emission, and ultimately the biodegration is rapid which avoids environmental hazards. The fatty acid composition in vegetable oil can affect the properties of generated biolubricant. Biolubricants are used in the lubrication of chain saws, machining and metal working. They are also used in the form of grease, particularly for large sized objects. Survey says that, biolubricants have given satisfactory result in terms of performance but are 30 to 40% costlier than synthetic or conventional lubricants [4]. That could be the challenging aspect for the researchers of the field. Though the biolubricants have ecological benefits, but they are still struggling to make their way into the market as compared to the synthetic lubricants. But still the Research and development sector is working on a long term plan [7].

1.2 Kusum oil properties and Extraction process.

Kusum tree, Schleichera family, occur in southeast Asia and Indian subcontinent, provides Kusum seed. In seed extraction process, the fruit is plucked from the tree and fruit pulp is remove. This oil contains oleic acid(2-3%), strearic acid (2-6%) as well as cyanogenic compound. [3]
Various trends like density, calorific value, viscosity and cold flow properties were examined in the laboratory and results were satisfactory. Blends of kusum oil with diesel were made by varying the percentage of oil in it. KB10, KB20, KB40 is been compared to D100. KB showed 5.5% higher viscosity than mineral diesel and the heating value was much comparable to diesel[6]. But lacked in cold flow rate somehow, cause for diesel it was -9°C and for KM it was -1°C. So, it can be well suited for warmer climate regions. Large size of Kusum oil molecular, responsible for its higher viscosity and flash point than diesel. These properties of oil clearly depicts that it has potential to use as a commercial biolubricant. Extruder machine in oil mill is used for the extraction of kusum oil. Following equation used to find oil yield from kusum seed [2].

\[
\text{Oil yield} = \left( \frac{\text{OSO}}{\text{WSO}} \right) \times 100
\]

where, extracted weight is OSO & Kusum seed weight indicates as WSO

In the present investigation bio-lubricant was obtained from Kusum oil as an alternative to mineral based lubricants due to its nature friendly properties and availability.

2. Materials and Methods:
Kundu et al. applied Chemical techniques, chromatography and infrared spectroscopy to find out the area and nature of the cyanogenic mixes in Kusum oil. Perceptions demonstrate the cyanogenic mixes to be a piece of glyceride particles where one of the hydroxyl gatherings of the last is attached to the cyanogenic compound through an ether linkage. Chromatographic conduct of the segregated cyanogenic mixes further demonstrates that in any event two glyceride atoms are included. These glycerides are dominantly esterified with immersed unsaturated fats [6]. Acharya et al. examine the impact of decreasing Kusum and karanja oil's consistency by preheating the fuel, utilizing a shell and cylinder heat exchanger. The gained motor information were examined for different boundaries, for example, brake warm productivity, brake explicit energy utilization (BSEC), emanation of fumes gases. The exhibition of karanja oil was discovered in a way that is better than kusum oil in all regards [8]. Karthikeyan et al. perform transesterification on kusum oil to obtain Biodiesels. The outcomes show that the pressure start motor functions admirably and the force yields are consistent running with the chose biodiesels mixes at various burdens. The gained information are read for different boundaries, for example, exhaust emanation and smoke darkness [9]. Murmu et al. perform experimentation to obtain biodiesel from kusum oil utilizing esterification response followed by transesterification response in an in-house cluster reactor arrangement [10].

In present study, plain oil and with Multi-Walled Carbon Nanotubes (MWCNT) and cerium oxide (CeO2) nanoparticles were used for the modification of rheological properties of Kusum oil. Nanoparticles are taken at uniform concentration of 1 gm in 100 ml of tamanu oil. Nanoparticles are
homogenized by intensive ultrasonication for 30 minutes. Rheological properties of samples are measured in shear rate ranging 0-200 s⁻¹. Initially zero shear viscosity was measured for each sample by increasing shear rate and measure the point of first moment of rheometer bob.

3. Results and discussion

Viscosity shows the contaminant present in lubrication which helps to assess the life of lubrication oil. If the lubrication oil viscosity is high it indicates there are no foreign particles are accumulated in lubrication oil and if viscosity is less then it indicates shear thinning which shows the lubrication oil is mixed with water or other fuel. Very high or low viscosity results in the damage of machinery.

Figure 1 shows the variation of shear stress with shear rate on plain Kusum oil. It can be observed that there is reduction in shear stress with shear rate, which is an indicative of shear thinning behavior.

![Fig. 1. Variation in shear rate with viscosity for plain kusum oil](image)

Figure 2 shows the rheological properties with the dispersion of 1 gm MWCNT nanoparticles in kusum oil. Sample was prepared by 30 minutes intensive ultrasonication. The viscosity test was performed with the help of LMDV 200 viscometer. Lubrication oil sample was placed under the viscometer and speed set to 1 RPM at room temperature due to high viscous its unable to calculate. So reading was considered from 5 RPM and the rest of result are conducted with equal interval of time and constant temperature. The test was performed up to 200 RPM to know the efficiency of lubrication oil. It was observed that the presence of MWCNT nanoparticles has reduce shear thinning behavior.
Fig. 2. Variation in shear rate with viscosity for MWCNT- kusum oil bio nanolubricant

Figure 3 shows the variation in viscosity with shear rate for cerium (CeO$_2$ (IV)) nanoparticle based sample. It can be observed that shear thinning behavior decreases with dispersion of CeO$_2$.

Fig. 3. Variation in shear rate with shear stress for CeO$_2$- Jonnesial Princeps oil bio nanolubricant

It can be observed from the test results that shear thinning behavior reduces with the dispersion of nanoparticles at lower shear rate. However at higher shear rate, there is almost not improvement over shear thinning behavior observed. Figure 5 shows the comparative improvement in rheological properties. It can be observed that MWCNT nanoparticles are more effective in improvement of rheological properties.
4. Conclusion

In present study, shear viscosity of Jonnesial Princeps oil was experimentally analyze. The samples are prepared with MWCNT and Cerium oxide (CeO\textsubscript{2}) nanoparticles. There was 14% and 12% improvement in viscosity at lower shear rate was observed with MWCNT and Cerium oxide (CeO\textsubscript{2}) nanoparticles respectively. Dispersion of nanoparticles provides reduction in shear thinning behavior and hence improving the lubrication properties. Bio-lubricant provides a potential ecofriendly substation of mineral oil based lubricant. Detailed analysis are required to establish its behavior.

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