Study on Performance and Emission Characteristics of Four stroke Gasoline engine under Formulated Neem oil as base lubricant

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Abstract
An attempt is made in this paper to use the neem oil as a lubricant to operate a gasoline engine. Basically, the raw oil is modified twice through esterification method and made into Neem Trimethylolpropane ester (NTMPE). A four stroke single cylinder petrol engine is utilized to conduct experiments. Engine is lubricated under various blends of NTMPE with mineral oil. The performance and emission study is made under these blends of lubrication. The obtained results are compared with the outcome under petroleum oil mode of lubrication. The outcomes show that 10% drop in fuel consumption and marginal improvement mechanical efficiency is noticed when the engine is operated under NTMPE20-MO80 mode of lubrication. About 9% increase in thermal efficiency is observed under NTMPE20-MO80 blend. Emission results shows that 8% drop in unburnt HC and 10% lower CO, under various blends of biolubricants and petroleum oil. Particularly, when the engine is operated under NTMPE20 – MO80 mode of lubrication, lowest CO and unburnt HC are observed.

Keywords: Vegetable oil, Neem oil, Trimethylolpropane, Transesterification, Biolubricant

1. Introduction
Vegetable based lubricants are recognized as substitute to petroleum oils for the reason that they possess certain advantageous technical properties and it is eco-friendly. Plant based lubricants usually show high lubrication property, high VI, high flash point, low toxicity and low evaporative losses [1, 2]. But, it also has certain drawbacks namely low oxidative and thermal stability [3, 4]. To replace usual petroleum oil-based lubricating oils and synthetic oils, high oleic varieties of plant based oils are considered to be potential candidates because of their superior oxidative stability [5, 6]. Many literatures shows that, to overcome the low temperature fluidity and low thermal and oxidative stability of vegetable oils, chemical modification of vegetable oil, genetic modification of seeds and adding additives were recommended [7, 8].

A review is made on the latest developments in production of lubricants from plant based oils through chemical formulation methods namely epoxidation of vegetable oils, estolide formation and esterification/transesterification. Above mentioned methods shows that there is considerably increase in the physical properties of the base plant oils, and efficient to produce plant based lubricants [9]. Biolubricant production of Ester Trimethylolpropane (ETMP) was carried out through esterification of Fatty acid of Jatropha oil with Trimethylolpropane. It is reported that, the product was successfully synthesized to nearly 55%. Flash point was greater than 300 °C, pour point was observed as low as −30°C, and viscosity is 79 centipoises [10].
Experiment is carried out for the production of ester through esterification of Fatty Acid Rubber seed oil (FARSO) with TMP. It is reported that there is increase in the flash point, high Viscosity Indices (VI) and lower pour point with the esterification process. RSOTMP ester shows comparative physicochemical properties which can be utilize as efficient biolubricant base stock [11]. Through transesterification of Sesame Methyl Ester (SME) with trimethylolpropane, sesame seed oil lubricant was produced. Result shows that the viscosity index is 193, pour point is -21°C and flash point is 196°C. It as high potential as base stock for Sesame biolubricant formulation [12]. Coconut and palm oil is used as lubricants in four stroke engine were evaluated and performance was compared with petroleum based engine oil. It is reported that, with vegetable oil based lubricant there is increased fuel efficiency and reduction in concentration of oxides of carbon and nitrogen in the engine emission [13]. Experiment is carried out on pure petroleum oil, different blends of petroleum based oil and pongamia oil and pure pongamia oil as lubricants for the CI engine run with pongamia oil as biodiesel. Results show that there is drop in fuel consumption and highest thermal efficiency during medium and high load conditions is observed under the use of pure pongamia oil as a lubricant [14]. The alternative for mineral oil based lubricant, rapeseed oil based bio-lubricant in a VCR diesel engine is investigated. Results reveal that there is reduction in Cu, Fe, Al wear, ash and soot content in combined use of biofuel/biolubricant of rapeseed oil when compared to biofuel/mineral oil combination [15]. Study is conducted using alkyl-rapeseed oil methyl ester and mineral oil blend in definite proportions as two stroke crankcase lubricants. It is reported that alkyl-rapeseed oil methyl ester generates lower emissions which reduces green house gases, improves engine life due to higher lubricity. It also enhance oxidative stability of gasoline [16].

This paper presents the utilisation of Neem oil as engine lubricant for lubricating a four stroke S.I. engine. Through experiment, performance characteristics and emission study of the engine are determined under the blends of modified neem oil and mineral oil lubrication. The outcome of experiment are compared with those attain under petroleum oil lubrication.

2. Structural modification of Neem oil

In the first phase of oil formulation, Neem oil is transesterified with methanol to obtain their ester forms such as Methyl ester of Neem oil (MENO). Further, in the second phase, ester is again transesterified with Trimethylolpropane (TMP) to obtain Neem Trimethylolpropane ester (NTMPE) and it is referred as modified neem oil for the experimental study.

3. Properties of NTMPE oil

The physico-chemical properties of modified neem oil is shown in the Table 1.

| Properties       | NTMPE | Mineral Oil |
|------------------|-------|-------------|
| Flash point (°C) | 124   | 200         |
| Fire point(°C)   | 126   | 208         |
| Viscosity Index  | 240.73| 123         |
| Viscosity, 40°C (mm²/s) | 12.34 | 19.26 |
|------------------------|-------|-------|
| Viscosity, 100°C (mm²/s) | 4.469 | 1.28 |

4. Experimental setup
A single cylinder air cooled four stroke petrol engine developing 1.3kW at 4200 rpm is used to conduct experiments. The engine is attached to an electric generator for determining the performance. Figure 1 depicts the experimental setup to carry out the experiments.

![Figure 1. Experimental Set Up](image)

Methodology
Basically, NTMPE and mineral oil are blended in volume for different ratios such as 10 % NTMPE and 90 % mineral oil (NTMPE10-MO90), NTMPE20-MO80, NTMPE30-MO70 NTMPE40-MO60 and NTMPE50-MO50. The engine characteristics like SFC, brake thermal efficiency, mechanical efficiency are calculated. Further, emission components such as CO and HC are measured using flue gas analyzer.

5. Results and Discussion
5.1. Efficiency
5.1.1. Fuel Consumption
Figure 2 shows difference in Specific Fuel Consumption (SFC) with respect to Brake Power for various blends of NTMPE and mineral oil. The results revealed that, at higher load operations, the lowest fuel consumption is seen under the blend NTMPE 20 – MO80. About 10% drop in fuel consumption under this blend of lubrication is observed, compared to petroleum oil mode of lubrication. Though, engine consume more fuel to produce a kW power under the blends, NTMPE30-MO70, NTMPE40-MO60 and NTMPE50-MO50 modes of lubrication.

![Figure 2. Difference in BSFC with respect to brake power for blends of NTMPE and mineral oil](image)
5.1.2 Brake thermal efficiency

Figure 3 represents difference in brake thermal efficiency with respect to brake power for various proportions of NTMPE and mineral oil. The result shows that, at higher load operations, there is about 10% increase in brake thermal efficiency under the blend, NTMPE20-MO80, and it may be due to an increase in mechanical efficiency under the same blend. However, the engine efficiency is marginally dropped under the remaining blends of operation. The lowest thermal efficiency is observed under NTMPE 50 – MO50 mode of lubrication.

![Figure 3. Plot of thermal efficiency with respect to brake power for blends of NTMPE and mineral oil](image)

5.1.3 Mechanical efficiency

Figure 4 depicts difference in mechanical efficiency with respect to Brake Power for various blends of NTMPE and mineral oil. At higher load operation it is seen that the mechanical efficiency under NTMPE10-MO 90 and NTMPE20-MO80 mode of lubrications is marginally improved compared to mineral oil lubrication. However, mechanical efficiency under the blends, NTMPE30-MO70, NTMPE40-MO 60 and NTMPE50-MO 50 is lower than the mineral oil lubrication and the lowest efficiency is observed under NTMPE 50 – MO 50 mode of lubrication. The decrease in mechanical efficiency under the blends NTMPE 30% and above may be due to the effect of oleic acid quantity present in the fatty acid composition.

![Figure 4. Difference in mechanical efficiency with brake power for blends of NTMPE and mineral oil](image)

5.2 Emission Study

5.2.1 Carbon Monoxide (CO)

Figure 5 shows difference in CO emission with respect to brake power for optimum blends of bio lubricant and mineral oil. Engine emits about 10% lower carbon monoxide values under NTMPE 20- MO80 compare to petroleum oil mode of lubrication because of higher flash point and lower volatility.
5.2.2 Hydrocarbon (HC)

Figure 6 shows the difference in unburnt hydrocarbon with respect to brake power for optimum blends of bio lubricant and mineral oil. The results revealed that, at full load operation, there is about 8% decrease in unburnt hydrocarbon emission under NTMPE 20-MO 80 mode of lubrication compared to petroleum oil mode of lubrication.

The decrease in CO and unburnt hydrocarbon may be owing to the high viscosity compared to mineral oil. The high viscosity results in lower the engine friction. Lower the engine friction increases the volumetric efficiency of the engine, due to this quantity of air intake to the engine is more. Therefore, there is sufficient amount of oxygen is in the chamber to burn the fuel completely. It may be the reason why the emission is decreases under bio lubricant compared to petroleum oil mode of lubrication.

6. Conclusions

Lubrication under the modified Neem oil, blended with mineral oil is observed to be better than the pure mineral oil lubrication. The blend, NTMPE20-MO80, found to be the better lubricant in terms engine performance and emissions compared to the petroleum oil lubrication in the engine. The mechanical efficiency of the engine is marginally improved under NTMPE20-MO80 blend type of lubrication compared to petroleum oil. Engine consumes about 10% less fuel under NTMPE20-MO80 blend of lubrication compared to mineral oil. The thermal efficiency of the engine is improved by about 9% under this mode of lubrication. Further, emission characteristics under NTMPE20-MO80 blend shows there is about 10% drop in Carbon monoxide emission and unburnt hydrocarbon emission is decreased by 8% compared to mineral oil mode of lubrication.
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