RJC

RASĀYAN *J. Chem.*
Vol. 10 | No. 3 |1050 - 1055 | July - September | 2017
ISSN: 0974-1496 | e-ISSN: 0976-0083 | CODEN: RJCABP
http://www.rasayanjournal.com
http://www.rasayanjournal.co.in

EXPERIMENTAL ANALYSIS ON NANOLUBRICANTS USED IN MULTI CYLINDER PETROL ENGINE WITH COPPER OXIDE AS NANOPARTICLE

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ABSTRACT
Now a day's, nanoparticles are extensively used to increase the thermal conductivity, heat transfer rate and tribological properties of the engine lubricant by adding nano additives to form nanofluids. Accumulation of nanoparticles in engine lubricant may reduce friction with the improvement of the lubrication characteristics. In order to reduce the friction and wear lubricants are used, but still, the fuel consumed for frictional losses is about ten to twenty percentages of the total fuel supply. This research work focuses on the preparation of nanolubricants by selecting suitable commercial engine oil, biodegradable oil and nanoparticles based on tribological performance for multicylinder petrol engine applications. The copper oxide nanoparticles and SAE15W40 commercial engine oil and punga oil as biodegradable oil used. The nanolubricants were prepared by adding nanoparticles to the base oils with 0.1% concentrations. From the results it was found that, SAE 15W40 with 0.1% copper oxide is the best nanolubricants for the applications multi cylinder petrol engine.
Keywords: Nanoparticle, CuO, SAE 15W40 oil, Punga Oil, Multicylinder Petrol Engine.

INTRODUCTION

On the subject of the significant role of nanoparticles on the lubrication oil efficiency, particularly during very high loads and pressure, nanotechnologies is an important technology by reducing friction and wear of the internal combustion (IC) engine and also cost reduction of fuel consumption. Existing and future automotive engines would require more efficient engine oils, a situation that presents a new challenge for researchers and designers of finding ways of enhancing the tribological characteristics of internal combustion engines while achieving a reduction in fuel and lube oil consumption.[1-3] The power losses in automotive engines vary between 17% and 19% of the total energy generated. An improvement in the tribological performance of the lubricating oils and the piston ring assembly leads to an improved efficiency and fuel economy of engines because the friction between the piston ring and the liner accounts for almost 40% to 50% of the power losses.[4-6] Tribology is the study of friction, wear and lubrication of act together surface in relative motion like rolling and sliding in engines creates huge friction and wear on the surface of the material. This cause's huge loss over a period of time, to conquer the loss and efficiency improvement of the mechanical parts, the tribological study was started.[5-9] Wear leads to the material wastage and reduction of mechanical performance. The primary reason for wear and energy dissipation is called friction.[10-12] Lubrication is used to effectively control the wear and to reduce the friction and the method of improving the effectiveness to prevent the scratch in solid contacts is known as lubrication.[13-15] The lubricant additives are certain materials which are additionally included with the base oil to facilitate the wear and friction characteristics by provision for adsorption. It also improves the oxidation resistance, controls corrosion, acts as rust inhibitors, reduces the excessive decrease in lubricant viscosity at higher temperatures, increases the dispersion in oil and regulates the surface tension of the lubricant.[16-18]The nanolubricants are the combination of base oil, nanoparticles and surfactants/dispersants. In this, the Surfactants act in regulating the surface tension in the lubricant. These nanolubricants functions based on various mechanisms such as mending effect, exfoliation of nanoparticle, rolling effect, third body material transfer and formation of tribofilm, which makes the Nano lubricant much more effective than the conventional lubricants.[19-21]An investigation was carried out with a standard lubricant called racer-4 oil which is isolated through nanoparticles of Cu and TiO_2 with a dissimilar concentration of accumulation. By means of introducing nano particles with the lubricant, it was found that a progress in brake thermal efficiency which influence the fuel economy through frictional power retreating.[22-25] Various experimental analyses were performed for Copper oxide (CuO), Nano-Diamond and TiO_2 nanoparticles with SF oil of SAE30-LB51153 and base oil SAE30-LB51163. Their study has shown that the CuO nanoparticle has reduced the coefficient of friction compared to lubricants without nanoparticles.[26-29] They have also concluded that CuO nanoparticle has reduced this depth of wear scar compared with base lubricants. A study on the improvement of the anti-wear with customized palm oil with adding up of CuO and MoS_2 was made and the results revealed that, the CuO and MoS_2 nanoparticles were effective additives for incorporation into chemically modified palm oil and it has enhanced the anti-wear and extreme pressure properties by 1.5 times.[30-32] Advancement in the tribological performance of the lubricating oils and the piston ring assembly leads to an improved efficiency and fuel economy of engines because the friction between the piston ring and the liner accounts for almost 40% to 50% of the power losses.[33-37]Furthermore, controlling friction via the use of nanolubricants leads to a decline in the level of wear and an increase in the service intervals for which an oil change is required. Based on the above study, an attempt was made to prepare a suitable nanolubricant to reduce wear and friction of multi cylinder petrol engines.

EXPERIMENTAL

Nanoparticles Selection

Based on the literature review, the selection of the nanoparticles was considered and characteristics of the nanoparticles along with costing of the nanoparticles. According to the literature survey most commonly used nanoparticles for IC engines are Molybdenum disulphate, Copper, Nano-diamond, Graphite and Copper oxide. CuO nanoparticles were selected for this analysis. The selection of the base oil depends upon the thermal stability, viscosity index, boundary stability, cost and availability. Based on the above factors, SAE15W40 as a commercial lubricant and punga oil as biodegradable oil were selected. The surfactant-oleic acid was preferred for the preparation of nanolubricant. It was chosen, since it performs better than lecithin, especially at elevated temperatures.

Nanolubricant Preparation

During the nanolubricantpreparation, CuO nanoparticles were added to the base oils at 0.1%wt concentrations. Initially, a specific amount of nanoparticles were added with surfactant and a paste was made by manual stirring. The weight of the nanoparticles depends upon the percentage of the nanoparticles to be used and quantity of the base oil. The surfactant is used to increase the suspension time of the nanoparticles in lubricant. The electromagnetic stirrer was used for to mixing of the nanoparticles with surfactant and the base oil. A magnetic strip is kept in the nanolubricant and the magnetic strip starts moving and rotates inside the lubricant when we switch on the magnetic stirrer. Magnetic stirring is run for minimum about 30 minutes to obtain the proper mixing of nanoparticles with the base oil.

Viscosity Test

The red wood viscometer was used to measure the kinematic viscosity of base oils at different temperatures. The kinematic viscosity of copper oxide based nano lubricants was measured at different temperatures and the values were found to be higher than that of the base oils. Fig.-1 shows the comparison results of kinematic viscosity for Nano-lubricants with 0.1% CuO based punga oil and SAE 15W40 lubricant. The kinematic viscosity of nano lubricants was measured at different temperatures of 30, 60 and 90^{o}C respectively.

Flash and Fire Point

Clevel and open cup apparatus was used to find out the flash and fire point temperatures of base oils. The flash point temperature exhibits the lowest temperature at which vapors of the oil ignite, under the source of ignition and when the source of ignition is removed, vapor may cease to burn. The fire point temperature, exhibits the temperature at which the vapor produced by the oil continues to burn at least for 5 seconds after ignition by the open flame. These tests are performed to address the safety issues with the base oils, since lower the flash point greater the fire hazard. In this test, the flash point and fire point temperatures of abase oil of punga oil and SAE 15W40 lubricant were 260^{o}C flash point with 280^{o}C fire point and 200^{o}C flash point with 220^{o}C fire point respectively. The results showed that, these base oils had significantly higher flash and fire point compared to the base lubricant.

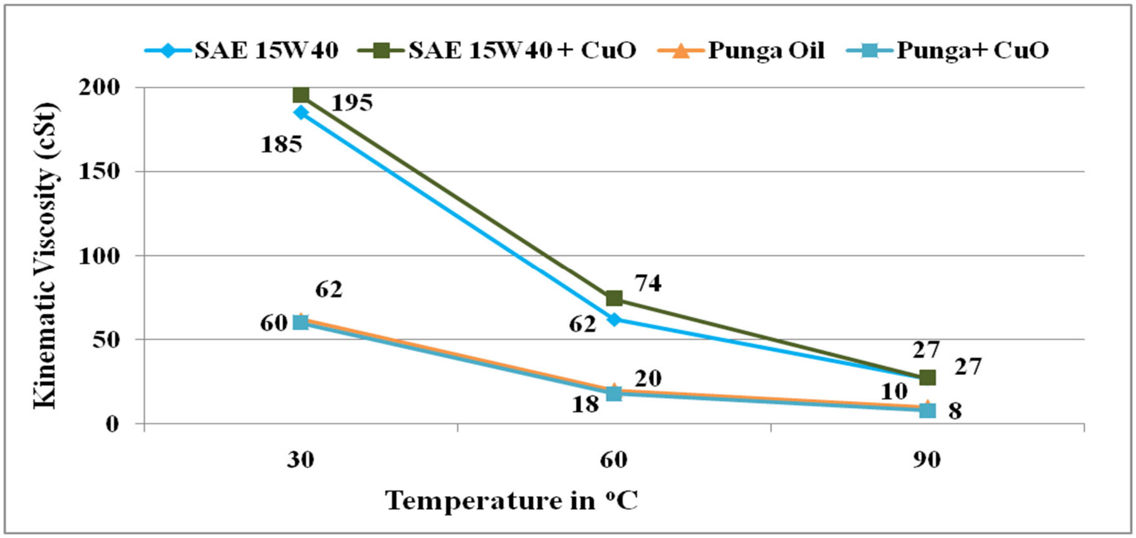

Fig-1: Kinematic Viscosity of Lubricants

Cloud and Pour Point

To study the properties of the base oils at low working temperatures the cloud and pour point temperatures were examined. The cloud point was obtained based on ASTM D2500-IP 219 standards. In this test, the base oil is taken half-filled in a test jar and placed in ice. For every 1^{o}C decline in temperature, the test jar is taken out to view, if there is any formation of cloud in the oil. The temperature at which formation of cloud appears is noted as the cloud point. After the appearance of cloud point, the temperature of the oil is further allowed to decrease and the point at which the oil completely gets clogged is noted as the pour point temperature. In this test, the cloud point and pour point of base oils is -20^{o}C and -24^{o}C and for SAE 15W40 and 6^{o}C and 3^{o}C for punga oil respectively.

RESULTS AND DISCUSSION

Tribological Investigation using RFM

To attain the coefficient of friction values for different lubricants at different working conditions the reciprocating friction monitor device is used. The reciprocating friction monitor has a reciprocating pin and a specimen of the fixed block over which the pin reciprocates. The diameter of the pin is 4mm and dimension of specimen block are 30mm x 30mm x 6mm. The lubricant is made to be present over the fixed block, in such a way that it acts as a film between the pin and block. The load is applied on the pin using lever arm and the specimen on reciprocating friction monitor is shown in Fig.-2 and Fig.-3 respectively.

The frictional force and the temperature are measured is calculated through load cell with high precision and resistance temperature detector respectively. The loading condition and speed of the reciprocating pin is chosen in order to simulate the working condition of IC engine. The experiments were carried out and the coefficient of friction was obtained for lubricants at different temperatures of 30^{o}C, 60^{o}C and 90^{o}C. In this test, the block specimen and the reciprocating pin used were made of mild steel. The block specimen was cleaned using acetone and placed in the holder.


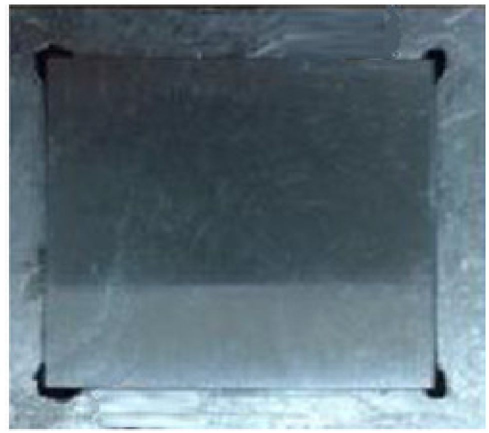

Fig.-2: Reciprocating Friction Monitor Fig.-3: Specimen for Testing

The test was conducted based on ASTM standards. The loading condition and speed of the reciprocating pin was chosen in order to simulate the working condition of IC engine. Tests were conducted for lubricants at 30ºC, 60ºC and 90ºC. The speed of reciprocating pin was chosen to be 1mm/s. The coefficient of friction was obtained for different lubricants at various temperatures and is shown in Fig.-4. The results of reciprocating friction monitor test,give the friction coefficient for lubricant. It could be inferred from the graph, that the punga oil with 0.1% CuO nanolubricant has low friction coefficient. The comparison also suggests that CuO based nanolubricants have good friction reduction properties.

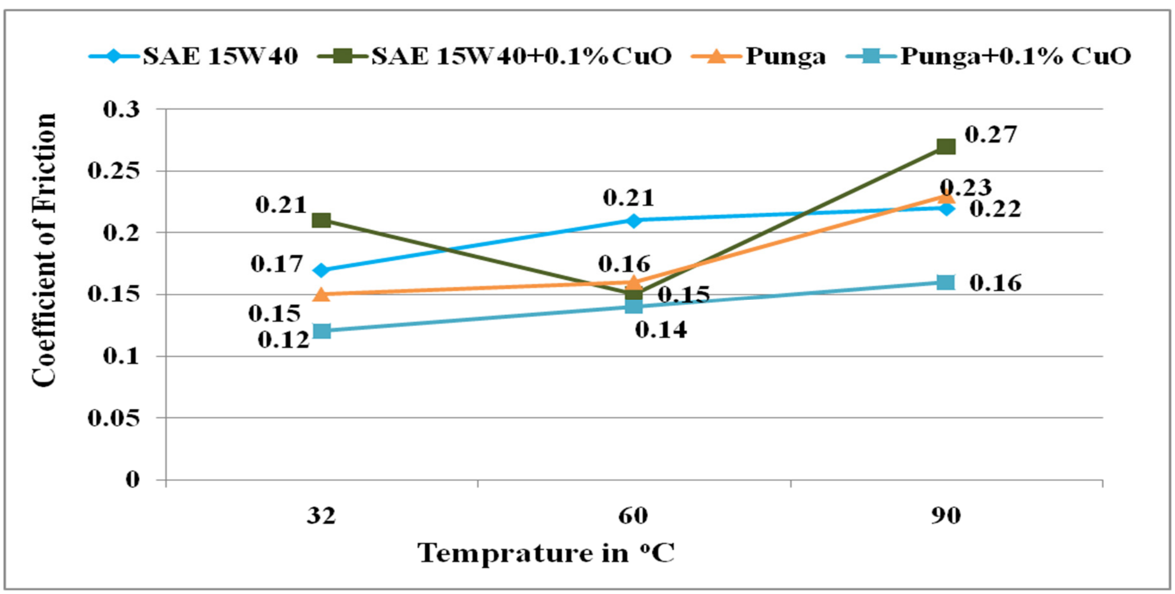

Fig.-4: Coefficient of Friction Chart

Analysis using Four Ball Testers

The wear test was carried out using four-ball tester and the wear test was carried out based on ASTM standards. In this test, three half-an-inch steel balls were clamped together and the lubricant which was needed to be evaluated was made to stagnate over the balls. The four half-an-inch steel balls were pressed to another clamp on the top, which presses against these three steel balls in the cavity formed between them with the force of 390N. This makes a three-point contact. The top ball was made to rotate at 1200 rpm for one hour.

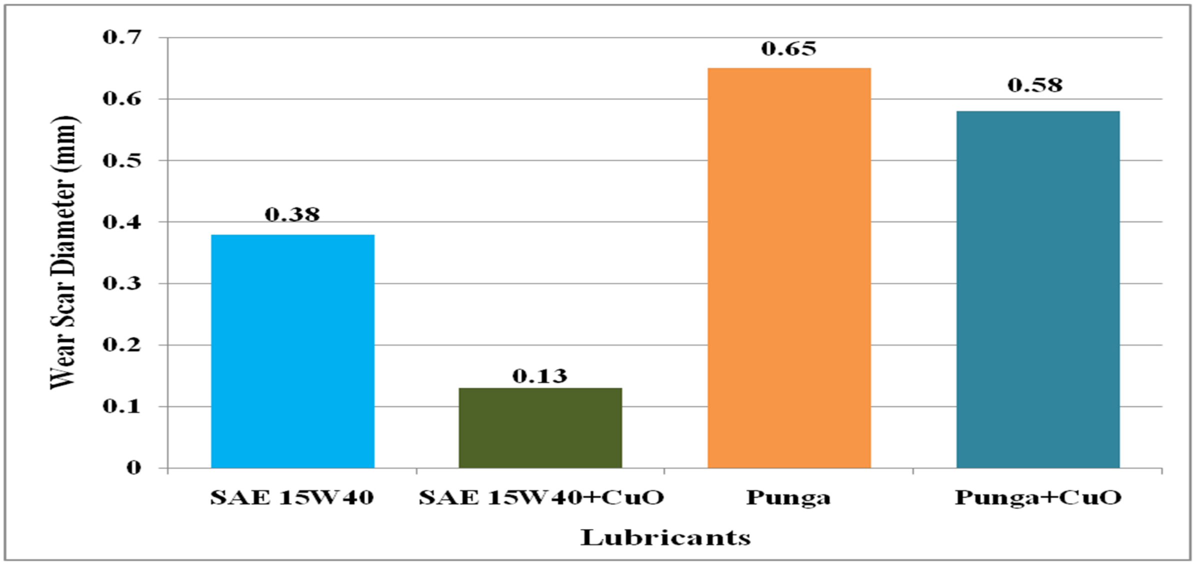

Fig.-5: Results of Four Ball Test

Once the test got over, the three balls were taken to examine the wear scar diameter. Based on the average size of scar diameter, of lower clamped three steel balls, the lubricants were compared. The results observed are given in Fig.-5 and from the results it was found that there were wear scar diameter for base oils, nanolubricants and SAE 15W40 lubricant. The maximum wear scar diameter of 0.65 mm was found in punga lubricant followed by 0.58 mm in punga with CuO lubricant. And also the results revealed that the SAE 15W40-CuO lubricant having good anti-wear properties with 0.13 mm wear scar diameter. In a larger perspective CuO based nanolubricants have shown reduced wear scar diameter compared to punga oil and SAE 15W40 lubricant.

CONCLUSION

Experimental analysis on nanolubricants SAE15W40 and punga oil prepared by adding additive nanoparticles of CuO to the base oils in 0.1% concentrations was done. From the obtained results the conclusions arrived are as follows.

- At working temperature between 60-80^{0}C, CuO with 0.1% based nanolubricant has performed better than commercial engine oil for multi cylinder petrol engine and hence the friction and wear of engine was found reduced.
- SAE15W40 with CuO nanolubricant have good anti-wear properties with wear scar diameter of 0.13 mm. But punga oil with CuO has better anti friction properties than SAE15W40-CuO lubricant.
- Conclusively, SAE 15W40 with 0.1% CuO nanolubricant is suitable for enhanced performance in multi cylinder petrol engines.

For further research nano fluids with different concentration may be used to get the better results.

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[RJC-1861/2017]