AMALGAMATION, PORTRAYAL AND EFFICACY OF HELIANTHUS ANNUUS BIO LUBRICANT WITH NANO ADDITIVE

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ABSTRACT

Owing to the hazardous contribution towards environment from mineral oil-based lubricants, bio-degradable lubricants extracted from vegetable oils seems to be a promising candidate considering climate change, energy security and green environmental approach. In this research work, chemically modified helianthus annuus is considered as a viable option due to its excellent tribological properties and considerable polyunsaturated fatty acid. To further enhance the tribological properties, copper oxide nanoparticles were added to the base oil in varying proportions of 0.2, 0.3 and 0.5% by weight fractions. The application of nano enhanced biolubricants on worm and gearbox is studied. The addition of copper oxide nanoparticles enhances dispersion stability of the biolubricant. Tribological characterization was conducted using pin-on disc machine. Tribological properties such as coefficient of friction and wear rate along with kinematic viscosity is analysed for each composition. The obtained results are compared with synthetic oil SAE 75. It is observed that with the inclusion of copper oxide nanoparticles to the biolubricant, there is a notable decrease in wear rate along with lower friction coefficient.

KEYWORDS: Nano enchanced BioLubricants, Nano Cupric Oxide, Recycliablity, Kinematic Viscosity, Anti-Friction.

1. INTRODUCTION

Various researchers across the globe are shifting their focus towards renewable source of lubricants due to increase in energy demands, diminution of fossil fuel reserves, increased environmental hazards and climate change [1]. Bio – lubricants were used until the 19th century and with the invention of internal combustion engines replaced the bio – lubricants with mineral oil-based lubricants due to its high stability. With increase in toxicity risks, bio-based lubricants are being extensively explored.

Lubrication is the process or technique of using a lubricant to reduce friction and wear. Lubricant is a substance that reduces friction, heat and wear when introduced between solid surfaces. Lubricants can be solid, liquids or gases which when imposed between two layers, it acts as a layer of separation avoiding asperities of the surfaces getting into contact. Adequate lubrication allows smooth, continuous operation of machine elements. Numerous mechanical systems require different lubricants according to their functions, so that the total energy consumed can be reduced by decreasing the friction and wear of contacting surfaces. It has been suggested that the mechanism behind friction reduction is due to mending effect, rolling effect, protective film formation, third body material transfer, transfer films and formation of tribofilms. Many researchers have tried to improve the lubrication characteristics of general lubricants. The lubricant oils are generally made from three main categories such as mineral oil, synthetic oils and vegetable oil. The lubricant oils which are conventionally used in industries are mineral oils (petroleum based oils) and synthetic oil. Most of the lubricant which used in industries leads to environmental hazards when it is dispersed due to its poor degradability. To overcome this, environment friendly and bio-degradable vegetable oils are used. The use of renewable source not only enables efficient carbon cycling but also reduces carbon emissions. The use of vegetable oils for lubricant applications is very significant in terms of protecting the environment. Biodegradable oils are used as alternative to petroleum based oils because they are renewable, non-toxic, biodegradable and environmental friendly. They also have important lubricant properties like high viscosity index, low volatility, good lubricity and an excellent solvent for additives. Biodegradable oils help in improving the surface roughness.

1.1. Necessity of Lubricants:

Proper use of lubricants contributes towards increased life of equipment, minimize friction and wear between two mating surfaces, extract heat, sometimes to protect the parts from corrosion and acts as a cooling medium.

1.2. Iniquity Possessions of Mineral Oil: Mineral oils are nothing but petroleum based oils.In earlier days mineral oil is used as lubricant for many applications such as machinaries,gears,compressors etc. In normal operating temperature mineral oil performs well,providing perfect lubrication at oil bath temperatures of up to 80°c. Mineral base oil show a significant decrease of kinematic viscosity and tendency to form sludge with rising temperature. Low biodegradability, High eco toxicity, Mineral oil on combustion give rise to nitrogeneous fumes, carbon monoxide and co_2, as soil is an environment for a variety of micro organisms and higher living organisms it is contamination with petroleum based lubricants becomes hazardous and a detrimental effect on biological life may occur. Proper functioning of the ecosystem may be disturbed. Disposal is again a major problem.

1.3. Efficiency of Biodegradable oil: They are renewable, Non-toxic, Biodegradable, Environmentally friendly, High viscosity index, Low volatility, Good lubricity and Biodegradable oils helps in improving the surface roughness**.**

1.4.Selection of CuO as nano additive:

CuO in addition to mineral oil exhibit good friction reduction and antiwear property. Addition of nano CuO to chemically modified rapeseed oil showed good friction reducing property and improves the surface roughness.Since nano CuO is too soft its particle does not causes any wear.Addition of nano CuO in mineral oil shows high thermal conductivity than mineral oil. Moreover CuO particles are insusceptible to oxidation, which makes them an effective high temperature additive and also showed the stability over 8 months period.Numerous researchers have reported that lubricants with nano particle additives were effective in decreasing wear and friction than conventional lubricant. The results of several investigations reported that the metallic nano particles added to lubricants could improve the anti-wear properties under extreme pressure (EP) conditions. The metallic nano particles could act without any corrosive effect and also could be used at high temperatures.

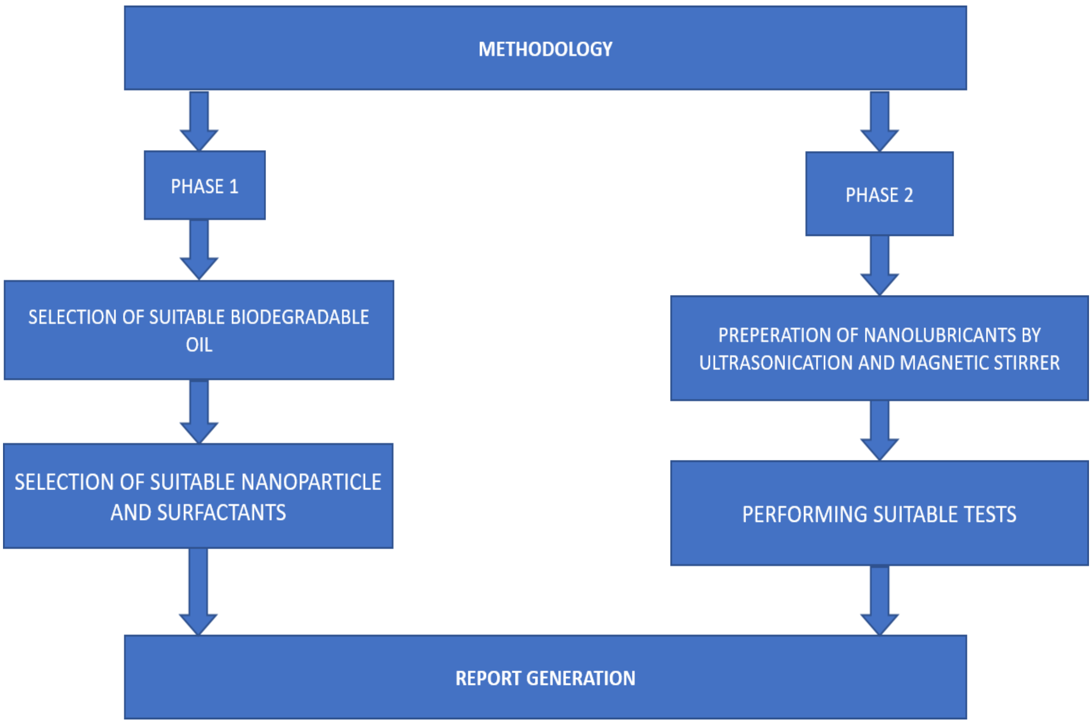
1.5. Assortment of sunflower oil as base oil

A stable lubricant film is formed by presence of more polar function group, thus sunflower oil has more polar function group.The sunflower oil form a thick film of about 8-12nm which helps in reducing friction.It is found that oils which have high fatty acid composition are desirable in boundary lubrication and plays a vital role in reducing friction, sunflower oil has high fatty acid content.

2. MATERIALS AND METHODS:

2.1. METHODOLOGY

This paper communicates to develop and test nano particulate biodegradable lubricant for worm gear and gear box application.



Most of the lubricant which used in industries leads to environmental hazards when it is dispersed due to its poor degradability. Biodegradable oils are used as alternative to petroleum based oils. Among these biodegradable oils sunflower oil have many attractive inherent advantages such as high viscosity index, good lubricity, low volatility and has the ability to form boundary film. A number of strategies has been developed to improve the anti wear property, extreme pressure property and possess good coefficient of friction but these strategies require treatment such as magnetic stirrer, probe sonication and ultrasonication for the dispersion of nano material into the base oil.

Here the nano material chosen is the nano CuO because it is one of the softest metals and possess excellent load carrying capacity good anti wear and friction reduction property. CuO form a boundary film to provide an anti-wear function and load carrying capacity. Here the surfactant used is oleic acid because the base oil is non polar solvent. The typical shape profiles and size of nano CuO is shown in fig 4.1.Its typical shape profile is in rod shape. The diameter is in the range of 23nm to 90 nm, and its average diameter is 45nm, and its elemental composition is shown in fig 4.2. From the xrd result as shown in fig 4.3, the peaks show the crystallinity of CuO and it is monoclinic in nature. The physical properties of base oils are shown in table 4.1.

Properties	**Sunflower oil**
Kinematic viscosity at 40 °C (mm2 /s)	**39.9**
Kinematic viscosity at 100 °C (mm2 /s)	**8.6**
Viscosity index (VI) 206 Density (g/cc)	**910**

Table 1 Physical properties of base oil

Appearance: Copper oxide nano powders appear to be brownish black powder.

Density	6.31 g/cm³
Melting point	1201°c
Boiling point	2000°c
Molar mass	79.55 g/mol

Table 2 Physical and chemical properties of Nano CuO

2.2. PREPARATION OF NANO LUBRICANT

Bio-degradable oil like sunflower oil has been chosen in this study. The base oil was inactive with the nano additive CUO. The physical properties of the base oils are already given in table 4.1.The nano additives when added to the oil starts to agglomerate and settle down at the bottom. Hence oleic acid, a surfactant was added in the ratio 2:1 weight composition of the nano additive to prevent agglomeration. The nano additive lubricant can be prepared by mixing nano particles and oleic acid and made to stir manually for 5 minutes. The nano lubricants were dispersed using magnetic stirrer. The process was carried on for four hours. Nano lubricants were prepared with 0.2 % 0.3 % and 0.5% of CUO weight fractions in sunflower (SO).

Fig 1. Magnetic stirrer

Fig 2. Digital weigh balance

2.3. RECYCLABILITY OF NANO CUO

After the agglomeration of cuo the nano cuo is recyclable, and the resulting vegetable oil is biodegradable. Nano cuo is recyclable upto four cycles without loss in catalytic activity. It is used as catalyst in the preparation of phenols, aldehydes, malononitrile, aryl halides etc.

2.4TESTING OF ANTI-FRICTION PROPERTIES USING PIN-ON- DISK TRIBOMETER

The anti-friction properties of lubricants are tested using pin-on-disk tribometer. The pin on disc tribometer is shown in fig 3.

PIN	**Brass, Medium carbon steel,8 mm diameter, 30 mm in length with grinded ends on both**
DISC	**Steel disc, radial distance 140 mm**

Table 3 Material specifications for pin on disc experiment

Fig 3. Pin on disc tribometer

The anti-friction properties of lubricants are tested using pin-on-disk tribometer. The friction and wear experiments were performed using pin-on-disk tribometer

. In this study, experiments were conducted using nano lubricants prepared with CuO and with sunflower oil and synthetic gear oil. Here the synthetic gear oil used is SAE75.The pin-on-disk tribometer contains stationary pin and rotating disk. The specifications for pin and disc is shown in table 4.2. The material for pin was chosen as brass and medium carbon steel because of worm gear and gearbox application.Fig 5.1. presents the specifications of specimen used. The rotating disk was made up of steel. Test intervals of 10 minutes were calculated using sliding velocity and sliding distance. Specimen was cleaned with acetone before testing. The specimen's initial and final weights were measured before and after testing. With that decrease in weight, wear rate was calculated and using frictional force and applied load, co-efficient of friction was calculated.

LOAD (N)	TIME (SEC)	SPEED(RPM)	SLIDING VELOCITY (m/s)
100	600	1000	7.33

Table 4. Pin on disc setup specification

2.5. TESTING OF KINEMATIC VISCOSITY USING REDWOOD VISCOMETER

Fig 4. Redwood viscometer

The viscosity of nano lubricant is measured using redwood viscometer.50ml of oil was used for each trial. Time required for emptying 50ml oil was measured and viscosity was calculated using redwood formula. Three trials were conducted for each sample and the average values of time are tabulated in below table 4. Kinematic viscosities were obtained at a temperature range of 50°c- 70°c.

NAME	TEMPERATURE		
	50°c	60°c	70°c
Sunflower oil	136 s	125 s	110 s
M1	260 s	204 s	165 s
M2	271 s	213 s	172 s
M3	300 s	223 s	180 s
M4	216 s	184 s	160 s

Table 5 Time taken in secs for various lubricants

Redwood formula

(mm^2/s)

Where V = Kinematic viscosity in (mm^2/s) T = Time of flow in sec

A and B are constants. The value of

A = 0.264 and B = 190,when t = 40 to 85 sec A = 0.247 and B = 65,when t = 85 to 2000 sec

Calculation

From the table all the time values are above 85 secs so the second constants values are choosen.

= – /

= (0.247*136)-(65/136)

=33.11 (mm^2/s).

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NAME	TEMPERATURE		
	50°c	60°c	70°c
Sunflower oil	33.11	30.355	26.57
M1	63.95	49.868	40.36
M2	67	52.305	42.1060
M3	73.88	54.789	44.098
M4	53.05	45.09	39.1137

Table 6. Kinematic viscosity of various lubricants in (mm^2/s).

Charecterisation of NanoCuO:

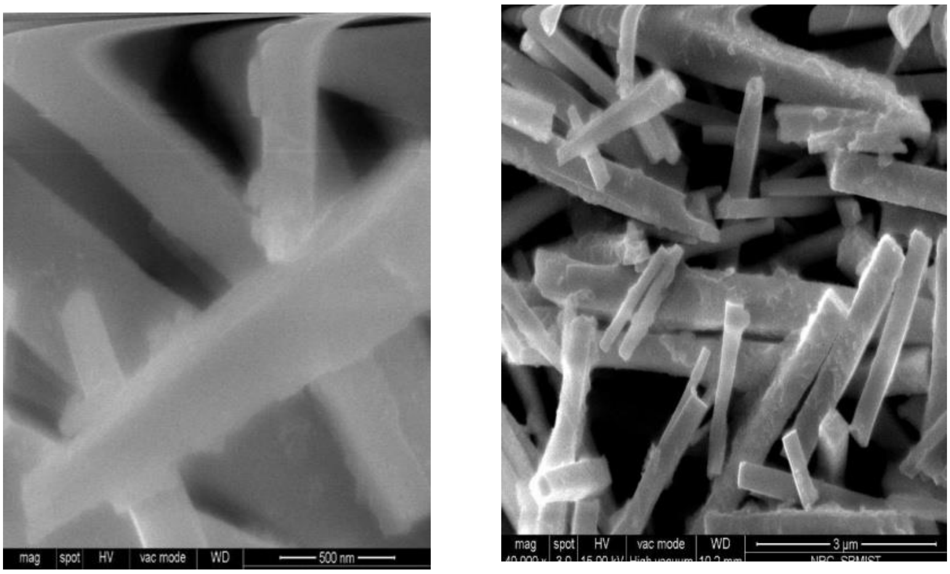

Fig 5. Sem image of CuO

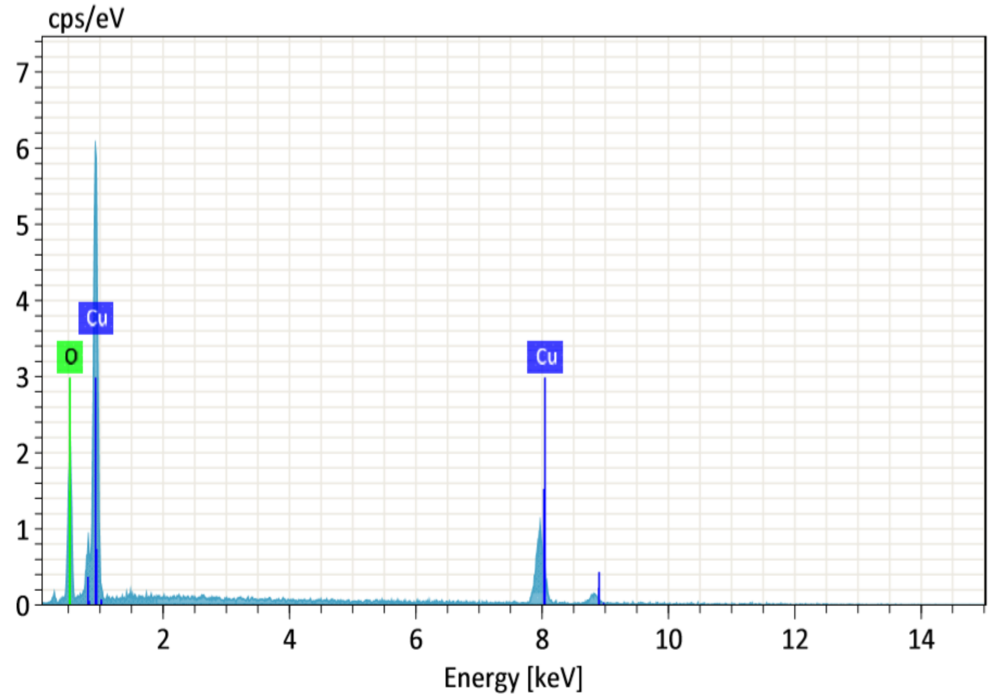

Fig 6. Edax graph

ELEMENT	MASS NORM [%]	ATOM [%]
COPPER (Cu)	80.15	50.41
OXYGEN (O)	19.85	49.59
TOTAL	100.00	100.00

Table 6. Elementary composition of CuO

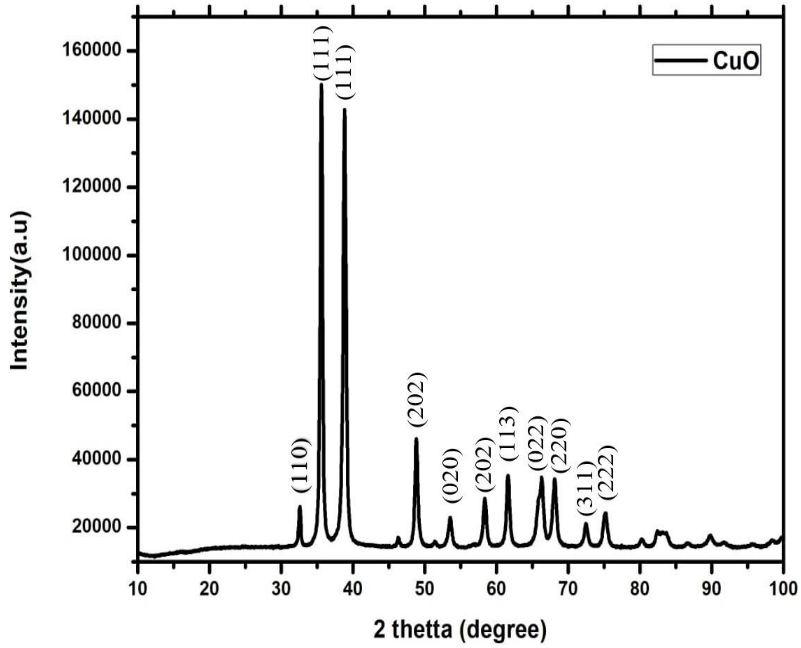

Fig 7. Xrd data

3.0. RESULTS AND DISCUSSIONS

3.1WEAR IN GEARS AND ITS ADVERSE EFFECT

Surface wear is one of the several failure modes experienced at the interface of lubricated gear tooth contacts that must operate under combined sliding and rolling motions. Apart from the direct material loss that leads to functional failure, surface wear causes the gear system to change its vibration and noise characteristics significantly as the gear mesh excitations are very sensitive to surface geometry. surface wear affects the pattern of gear contact in such a way that contact stresses and load distributions are altered the occurrence of failure modes. So, the wear plays the important role in gears.

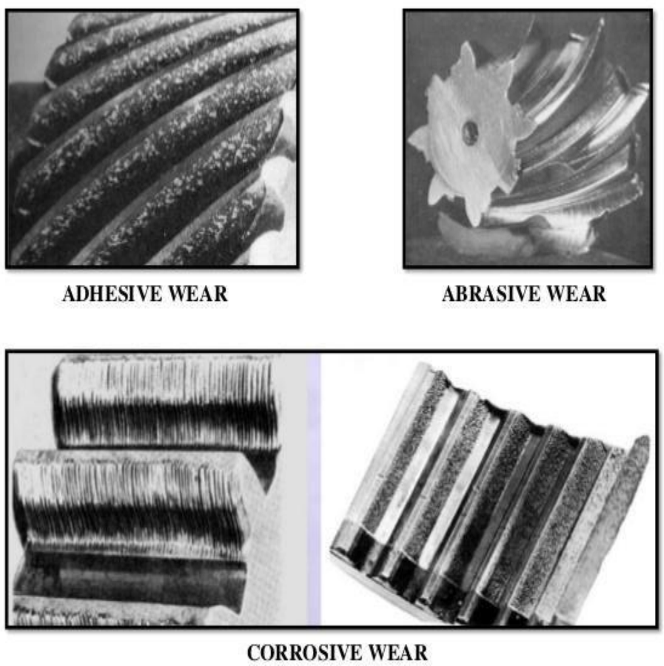

Fig 8.Adhesive wear, Abrasive Wear and Corrosive wear

3.2ANTI-FRICTION AND ANTI-WEAR PROPERTIES

Anti-friction and anti-wear properties indicates that by the addition of CuO to bio-degradable oils, significantly reduced the friction and wear at the interface. The graphs are plotted for 100 N and 4398 m distance. From the Fig. 6.2 and fig.6.4 it is seen that the co-efficient of friction is reduced in nano lubricant, compared to the synthetic gear oil.

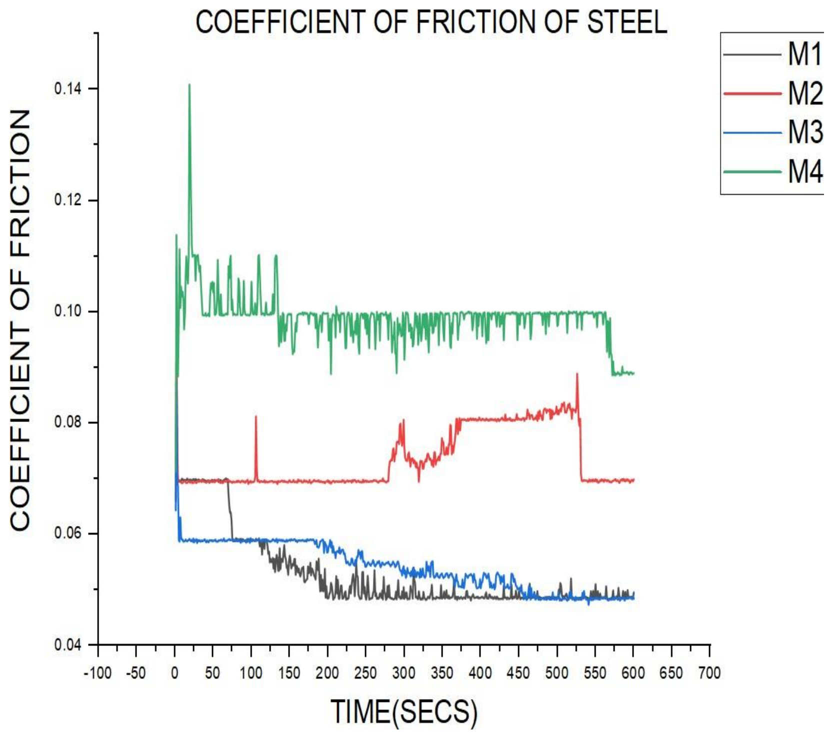

Fig 9. Coefficient friction of Steel

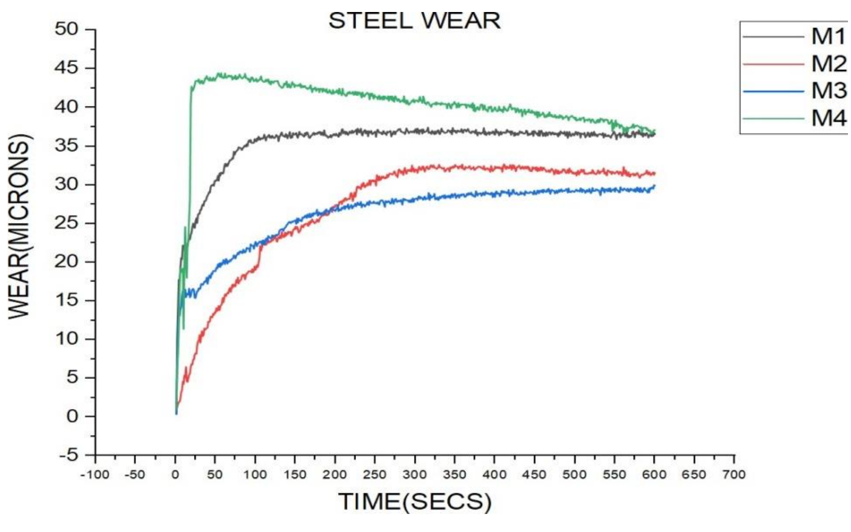

Fig 10. Steel Wear

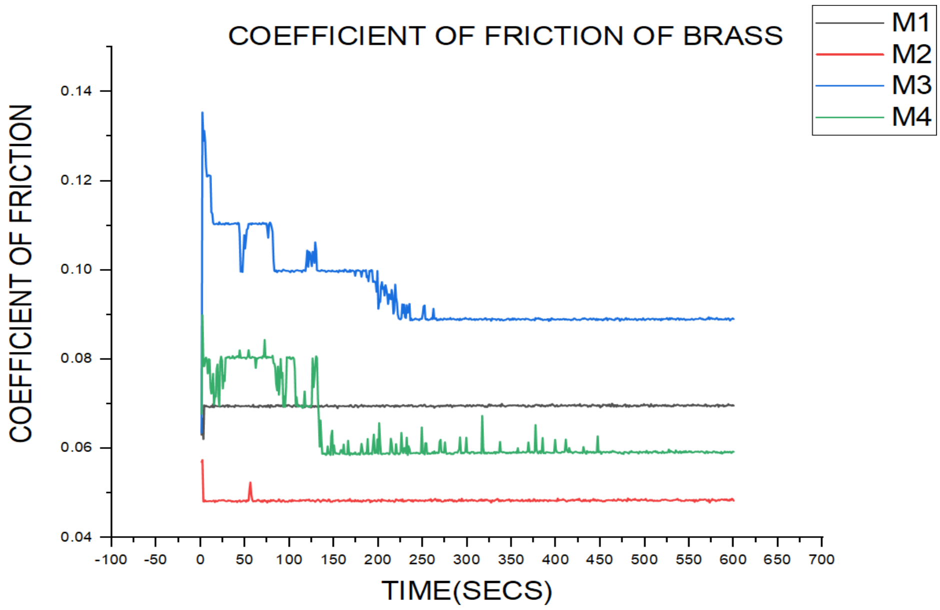

Fig 11. Coefficient Friction of Brass

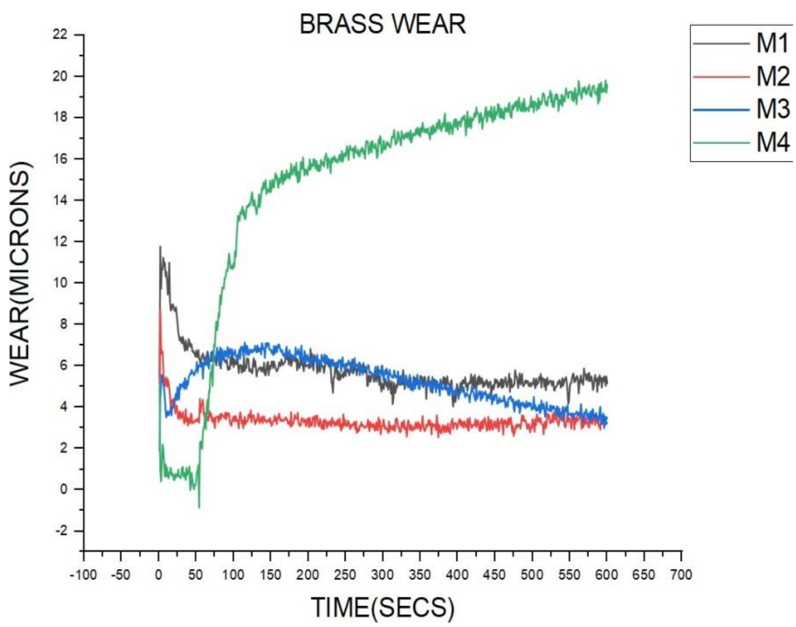

Fig 12. Brass Wear

The nano particles form a tribo-film at the interface and acts as a sacrificial layer. It fills the asperities and helps in reducing the wear of the specimen. The coefficient of friction is reduced in fig.6.2 and fig 6.4 because, the nano particles present in between the surface act as a load bearing element and it reduces the friction between the surfaces. The sunflower oil forms a thick film of about 8-12 nm have low wear rate than the synthetic gear oil. It is seen from the fig that the nano lubricant has smoother surface. It shows that wear is less in those surfaces whereas, synthetic gear oil have poor surface, because the wear rate is high in those surfaces. The wear is less in CuO because mending effect takes place.

3.3KINEMATIC VISCOSITY

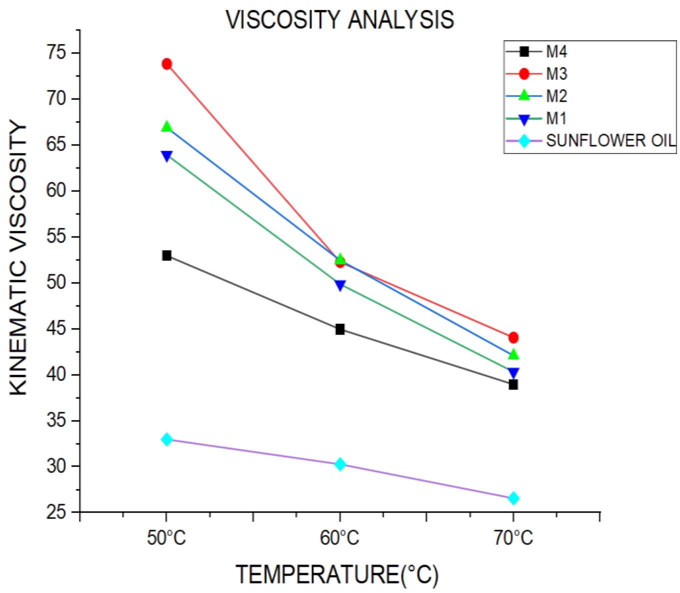

Fig 13. Viscosity Analysis

The viscosities of the nano lubricant at various temperatures and at various nano particle concentrations have been measured using Redwood Viscometer. Three trials were conducted for each sample and the average value are taken for analysis.The fig. 6.5 shows the kinematic viscosity analysis graph.

4.0. CONCLUSION

The bio-degradable nano lubricants were prepared with CuO and sunflower oil. Magnetic stirrer was used for proper dispersion of base oil and nano additives using oleic acid as surfactant. Co-efficient of friction and wear rate were analysed on pin-on-disk tribotester. Kinematic viscosity were analysed using redwood viscometer. Based on the results of the present experimentation, following conclusions were drawn:Friction and wear test on pin-on-disk tribotester showed that addition of nano additives in the base oil improved the anti-friction and anti-wear properties.In case of steel increase in concentration of nano particle decreases the wear content. The lubricant with 0.5% of CuO shows the lowest wear while synthetic oil shows the highest wear.While in case of brass increase in time period, the lubricant with 0.5% of CuO shows an exponent decrease in wear, while 0.3% and 0.2% shows the constant wear rate.From this we conclude that increase in concentration of nano particles decreases the wear.The mechanism of friction reduction was due to the formation of tribofilm through the deposition of CuO nano particles on the wear surface.In case of steel the lubricant with 0.2% of CuO has low coefficient of friction, while the synthetic oil has the highest coefficient of friction.In case of brass the lubricant with 0.3% shows the least coefficient of friction while the lubricant with 0.5% of CuO shows highest coefficient of friction.As expected the viscosities generally decreases with increase in temperature. From the experiments it is observed that the kinematic viscosity increases to some extent by addition of nano particles. At higher temperatures, increase in viscosities is observed for higher temperatures. At higher temperatures, decrease in density has caused larger variation in kinematic viscosity.

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