Tribological Investigation of Additives Blended in Bio-Lubricant with Synthetic Oil for Enhancing its Feature

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ABSTRACT

Designing, tolerating, as well as maintenance procedures for any product, rely heavily on tribology. Typically, it is assumed that any mechanical device, such as brakes, bearings, bushes, etc., will operate more efficiently if both friction and wear are decreased. It is very likely that the mean time to failure, or the product's life, will grow. However, simply designing the components with appropriate tolerancing will never be enough to eliminate the issue because there is always a potential that friction will exist between mating components in a product assembly, leading to wear. Therefore, it is always reduced by utilizing a mediator that, in essence, reduces friction to reduce wear. that is, by lubricants. Since mechanical items such as power transmission drives, such as gear boxes, power trains, engines, shock absorbers, etc. are subject to extremely high temperatures and intense pressures, lubricants find lucrative applications in such applications. Because of the way lubricating oil is designed and maintained, it frequently succumbs to these severe environments and loses vital qualities including viscosity indices, extreme pressure resistance, and temperature retaliation.

Keywords: Tribology, bio-lubricant, multi-walled carbon nanotubes etc.

I. INTRODUCTION

Compared to lubricants made from minerals, vegetable oils are renewable and biodegradable. However, they have some inferior technological characteristics. This experiment uses the bio-lubricants are concerned with questions of environmental contamination, toxicity, and cost. In order to enhance its anti-wear and anti-friction capabilities, this paper compares the performance of SAE 20W40 with a blended version of it that contains bio lubricants. This has encouraged research into creating and utilising base oil and bio lubricant as an environmentally friendly lubricant. In terms of their application as lubricant base oils, Karanja and castor oil generally offer outstanding qualities such as

- high viscosity index
- high lubricity
- high flash point
- low evaporative loss
- high biodegradability and
- low toxicity

for example. Here, we provide an overview of the generally acknowledged method used across the world to evaluate the tribological features of lubricating oil. According to ASTM standard D4172B protocol, a four ball tester was used for tribological testing.

And also with the help nanoparticle's we will advancing the features of blended oils with all possible combination

When compared to other oil combinations, the 20% contribution of Bio lubricant can produce the best results

To When used as lubricant additives, nanoparticles can have three different anti-wear mechanisms: melting and welding on the rubbing surface, reacting with the specimen to form a protective layer, or tribo-sintered on the surface. Some researchers claim that nanoparticles can also function as small bearings when rubbing surfaces. Lubricated EHD contacts are penetrated by nanoparticles, which create a boundary layer that, by mechanical trapping, affects friction and wear. These nanoparticles are only entrained into sliding contacts when the film thickness is smaller than the particle size contributing to the film thickness. The anti-wear properties of the nanoparticles only become active in mixed and boundary lubrication. According to the findings, nanoparticles can enhance base oil's tribological characteristics by reducing friction and wear even at concentrations as low as 1% by weight. However, they did not compare coated nanoparticles used as lubricant additives to non-coated nanoparticles in terms of their tribological behavior.

II. METHODOLOGY

Basic Oil Selection

Selection Criteria of Lubricating Oils in Industry:

- Use an industrial lubricant that is specifically formulated to fit the needs of your operation whenever possible. If you are prepared to do the study and have a foundational understanding of the subject, there are recent developments in lubrication that may prove to be more dependable or lengthen the life of equipment.

Oil – 20W40

Application - 20W40 is general purpose engine oil for all types of cars.

Specification of oil

Parameter	Value
SAE Grade	20W40
Viscosity(ASTM D445)	
Density	-
Viscosity at 30 °C	237.4
Viscosity at 50 °C	90.8
Viscosity at 70 °C	23.13
Viscosity at 90 °C	14.01
Flash Point in °C	208
Fire Point in °C	228
Density @ 15sss	

Table2.1.1 Parameters of 20W40

Bio lubricant Selection

Reason for selection of Bio lubricant:

I. Chemical modifications to plant-based oils, such as transesterification, epoxidation, and esterification processes, are typically used to create bio lubricants.

II. These lubricants have weak hydrolytic stability, minimal thermal oxidation, and poor cold flow characteristics.

III. Because it is renewable, biodegradable, and environmentally friendly, vegetable oil becomes effective. Lubricants with a vegetable oil basis can tolerate extremely high temperatures. They are equipped with an anti-aging supplement that makes them resistant to oxidation.

IV. Coconut oil, castor oil, Karanja oil and palm oil are the vegetable oils that are taken into consideration [23], whereas graphene and multi-walled carbon nanotubes are the friction-reducing materials [24].

V. Bio lubricants have a properties like

- high flash point
- high viscosity index and
- low volatility.

VI. It has been shown that castor oil contains around 84% fatty acids, with ricinolein acid being the main component, making it an excellent bio-lubricant [23].

VII. Triglycerides, which are composed of glycerol and other acids that are single, double, and triple bound and function as the reaction's active sites, are the main cause of the reduction in friction in vegetable oil [23].

Reason for usage of Nanoparticles in Bio lubricant & Synthetic oil blend :

Nanoparticles are used in nanotribology to overcome the drawbacks of using unprocessed vegetable oil, and because of their special qualities, they are classified as friction modifiers..

Bio lubricant Types and it's selection
Castor oil –

- At 40°C and 100°C, the kinematic viscosities and viscosity index of vegetable oils and bio-based lubricants [25]. The castor oil lubricant has the maximum viscosity. The increased viscosity of castor oil lubricant may be due to the higher content of ricin oleic acids (90%) in castor oils. The viscosities of the castor oil lubrication were the same as SAE Crankcase 20 [25]. It implies that between operating temperatures of 40°C and 100°C, the modified castor lubricant may provide a superior film thickness between gliding surfaces than the SAE Crankcase 40 commercial engine oil lubricant [25].
- The flash point of castor oil was 240°C, but it later rose to 251°C. Vegetable oils and their biobased lubricants have superior flashpoints than other commercial oils on the market [25], which were measured at 175°C [19].
- Castor oil's pour point increased by 66.7%, and both the oil and its biobased lubricants had lower pour points than conventional oil lubricants, which had pour points of -62°C. Compared to SAE 20 and 50, the pour points are much superior [25]. The findings suggest that the bio-based lubricant may still be utilized in diesel and gasoline engines in environments where their respective operating temperatures do not fall below -60°F and -60°C [19].

Karanja oil –

• It boasts the lowest COF of any vegetable oil and the lowest WSD of all lubricants based on vegetable oils [20].

• Its performance is on par with SAE 20W50 and SAE 40 and is significantly better than SAE 20W40 [21].The combination of an increase in the number of polar ester functional groups in the oil structure due to chemical modification and a dense fatty acid layer brought on by a high percentage of oleic acid is what causes oil to have a low COF and WSD [20]. It has good thermal stability and energy efficiency together with outstanding performance in terms of friction and wear characteristics [20].

Nano Particles

Additives :

A Additives is a tiny particle with a size range of 1 to 100 nanometres. The physical and chemical characteristics of nanoparticles, which are invisible to the human sight, might differ dramatically from those of their bigger material counterparts.

Nanosheets of MoS_2 When compared to an equivalent SiO2-doped lubricant, the MoS_2-doped lubricants demonstrated a considerably higher load-bearing capability[22]. As a thin film lubricant, liquid lubrication additive, and filler for composite materials, the lamellar transition metal dichalcogenide MoS_2 has demonstrated remarkable tribological characteristics. The creation of a protective thin coating enriched with MoS2 on the sliding surfaces was blamed for the better tribological characteristics[22].

GO The sheet-like lamellar structure is seen in the GO. Lamellar sheets GO Due to the micro ball-bearing effect, spherical nanoparticles prolonged the low friction, and the low shear strength of 2D lamellar sheets (GO) reduced the friction under tribo-stress [22].

MWCNT Thermo conductivity increased along with the concentration. The MWCNT nanoparticle's thermal conductivity at 0.1, 0.2, and 0.5 weight percent.

SR.NO.	Additives	Size	Shape
1.	SiO_2 (Silicon Dioxide)	20-50nm	Spherical
2.	MWCNT (Multi Wall Carbon Dioxide)	Diameter : 5-15nm , Length : 5µm	Nanosheets
3.	GO(Graphene Oxide)	Thick : 0.8-2nm, Length : 5-10µm	Nanosheets

Table 2..3.1 Selection of nanoparticles

Silicon Oxide Dispersion

Product Name : Silicon oxide Dispersion (SiO_2)

Size : < 15 Micron

Purity : 99.9%

Colour : White

Form : Powder

Molecular Formula : SiO_2

Solvent : Hydrochloric Acid

fig.2.3.2 Silicon dioxide .

Boiling Point : 2,230 °C

Price : Rs 50/gm.

Manufacturer : Adnano Technologies Pvt . Ltd ,Karnataka.

Multi –Walled Carbon Nanotubes .

Product : Multi-Walled Carbon Nanotubes
Outer Diameter : 10-20 nm.
Inside Diameter : 3-5 nm.
Ash : <1.4 wt%.
Purity : >96 wt%.
Length : 10-30 µm
Sp. Surface Area : 233.765 m2/g
Electrical Conductivity : >100 S/cm

fig 2.3.3 Multi wall carbon nanotubes

Bulk density : 0.22 g/cm3
True density : 2.1 g/cm3
Price : Rs 68/gm.
Manufacturer : Adnano Technologies Pvt . Ltd ,Karnataka.

2.3.4 Graphene Oxide

Product : Graphene Oxide.

Purity : 99.9%.

Molecular Weight : 12 g/mol.

Form : Powder .

Colour : Black High.

Thermal Expansion : 4.945 µm/m-K.

Thermal Cond. : 6.034 W/m-K

Tensile Strength : 18 MPa

Solubility : Soluble in water

Price : Rs 130/gm.

Manufacturer : Adnano Technologies Pvt . Ltd ,Karnataka.

Additives In Lubricating Oil

The anti-friction, chemical, and physical qualities of base oils (synthetic or vegetable) can be improved using additives, which improves lubricant performance and lengthens equipment life. The kind of lubricant (engine oils, gear oils, hydraulic oils, cutting fluids etc.) and the particular working circumstances (temperature, stresses, machine part materials, environment) define the combination of various additives and their proportions. Up to 30% of ingredients may be additions.

a) Anti-Oxidants.

b) Anti-wear Nano particles.

c) Detergent.

d) Rust and corrosion inhibitors.

e) Friction modifiers.

f) Extreme pressure (EP) additives.

h) Viscosity index improvers .

i) Pour point depressants.

j) Anti-foaming agents.

Concentration

Another crucial factor that affects the tribological properties of lubricating oils is the concentration of nanoparticles. According to the studies done in this area, the ideal concentration of nanoparticles is necessary to get superior tribological characteristics (Raina et al.). investigations that have been conducted with various nanoparticle concentrations. The majority of the studies' authors found that nanoparticle concentrations as low as 0.01 to 5wt% were sufficient to provide the enhanced tribological characteristics

GO- 1.8 nm thickness and 10nm by 100nm size. The authors reported improved tribological characteristics with concentrations comparable to 0.05 weight percent.

MWCNT-nanoparticles with dimensions of 10-20 nm in diameter and 5 µm in length are present in quantities ranging from 0 to 1 wt%. The authors reported improved tribological characteristics at a concentration of 1 weight percent.

SiO_2-nanoparticles with variable concentrations between 0 and 1 weight percent, 20 to 50 nm in size. With a concentration of 0.7 wt%, the authors reported enhanced tribological characteristics.

Sample ID	Base Oil	Bio Lubricant	Additives	Weight of additives in Base Oil+ Bio Lubricant.
A	20W40	-	-	-
B	20W40	Karanja	-	-
C	20W40	Castor	-	-
D	20W40	Karanja	SiO2+GO+MWCNT	0.75+0.45+0.15 = 1.30
E	20W40	Karanja	SiO2+GO+MWCNT	1.05+0.75+0.3 = 2.10
F	20W40	Karanja	SiO2+GO+MWCNT	0.45+0.15+0.075 = 1.35

Table 2.5. Additive concentration table

Anti-wear Additives

Based on their capacity to fill certain functions alongside a base oil in an application, additives are chosen. By their very nature, additives either provide base oil wholly new qualities, reduce unwanted ones, or give it entirely new properties. Depending on the application, additive packages might constitute up to 30% of the volume of the formed oil.

The most widely used additives for friction and wear management are typically either anti-wear (AW) or extreme-pressure (EP) additives. During mixed-film and boundary-film lubrication, these packages create sizable, chemically reactive groups that help to protect metal surfaces. They may not be actuated if full-fluid-film lubrication is maintained.

But once crowing surface asperities start making contact, they take on a sacrifice-like quality and offer the much-needed protection for the active surfaces. This continues until they are worn out, at which time surface deterioration starts to happen.

Although extreme-pressure compounds and anti-wear additives are sometimes lumped together under the same friction and wear control heading, there are significant discrepancies between the two functional packages.

During mixed-film and boundary-film lubrication, anti-wear additives are utilised to prevent wear and the loss of metal surfaces. Elevated loads or temperature at the contact surfaces initiate this package. In order to reduce wear, it functions to generate a protective coating. In this process, the additives interact chemically with the metal surfaces to shield them from wear, corrosive acids, and base oil oxidation. These additives generally consist mostly of zinc and phosphorus compounds, frequently in the form of ZDDP.

Extreme-pressure compounds adsorb to the surface of the material, whereas anti-wear additives chemically react with the surface to generate a low shear-strength coating. Additionally, temperature increases brought on by loads nearly invariably result in the formation of anti-wear compounds.

Extreme pressure (EP) additives

Additives for extreme pressure (EP) avoid seizure situations brought on by direct metal-to-metal contact between the parts when they are subjected to heavy pressures. Anti-wear additives and EP additives both work by covering the surface of the part with their additional ingredient. By shielding the component surface from direct touch with another part, this coating helps to prevent wear and scoring.

The following materials are used as extra pressure (EP) additives:

a) Zinc di-alkyl-di-thio-phosphate (ZDDP).

b) Molybdenum disulphide .

c) Multi wall Carbon Nanotubes.

2.5.3 Rust and corrosion inhibitors

Rust and Corrosion inhibitors, which provide a barrier layer on the substrate surface to slow down corrosion. Additionally, when they soak into the metal surface, the inhibitors create a coating that shields the component from the assault of oxygen, water, and other chemically active molecules.

The following materials are used as rust and corrosion inhibitors:

1. Alkaline compounds
2. Esters
3. Amino-acid derivatives

2.5.4 Anti-oxidants

Organic acids are created when mineral oils combine with airborne oxygen. The oxidation reaction's by-products lead to foamy corrosion of metallic components, a rise in oil viscosity, and the production of sludge and varnish. Oil oxidation is prevented by antioxidants. Antioxidants are included in most lubricants.
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III. Testing Methods.

Four-ball test machine

This study primarily used a four-ball analyser machine, which Boerlage, G. (1933) described for investigating lubricant attribute characteristics. Three balls are utilised at the setup's base, with one ball at the top. The three baseballs were examined, studied, and clasped instead of the top in a pot with lubricants. The four-ball tribo-tester's components include the collet, oil cup assembly, and ball bearings. Before every test, all parts' surfaces are cleaned with acetone. To gauge the temperature of the oil, a thermocouple was set up at the ball pot's base. At the foot of the ball pot, there was a warming device that controlled the temperature. In this investigation, a 40 kg weight was used for the wear test, which was run for one hour at 1200 RPM and a lubricant temperature of 75 RPM

Fig 3.1 : Four Ball Tester

Table 3.1.1 Mechanical Specifications

Sr No.	Part details	Range
1	Collate Diameter	12.45 mm
2	Plate height From floor	928 mm
3	Arm height from floor	1050 mm
4	Ball pot height from floor	1230 mm
5	Arm Length	935 mm
6	Arm Ratio	1:15
7	Max. Load	9999 N
8	Min. Load	60 N.
9	Dead Weight	In steps of 1,2 and 5 kg
10	Motor Height from floor	1580 mm
11	Pulley Ratio	1:1
12	Spindle Angular Velocity	Min 1000 rpm Max 3000 rpm
13	Overall sizes of the m/c LxWxH	650x940x1660 mm
14	Weight of the Machine	395 Kg
15	Floor Size LxW	1300X2300 mm

Ball material

The balls used in the experiment are made of AISI 52100 chrome steel [21] and have the following specifications:

- Yield strength of 2033 MPa.
- Diameter of 12.64 mm
- Hardness of 62–64 HRC
- High surface finish grade 25
- Density of 7.645 g/cm3
- Tensile strength of 2241 MPa

Fig 3.1.2 : Ball Material

Magnetic Stirrer

Included in the collet, oil cup assembly, and ball bearings are components of the four-ball tribo-tester. Each component's surface is cleaned with acetone prior to testing. To gauge the temperature of the oil, a thermocouple was placed at the base of the ball pot. At the base of the ball pot, a warming device controlled the temperature.

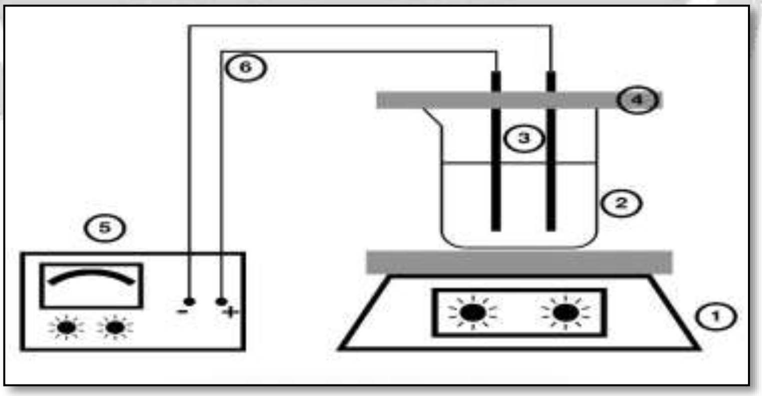

Fig 3.2 : Magnetic Stirrer

Cleveland's Open cup Apparatus

Cleveland's open-cup method, also known as the Cleveland's open-cup tester, is one of three primary chemical techniques for figuring out the flash point of a petroleum product. First, a particular amount of the product is added to the test cup of the equipment, which is typically made of brass. Then, when this chemical gets closer to the envisioned flash point, the temperature is raised swiftly and continuously. The chemical will start to emit flammable vapor in increasing amounts and density as the temperature rises. The chemical's flash point is the lowest temperature at which a little test flame passing over the liquid's surface causes the vapor to Fire. The chemical's fire point, which is thought to have been achieved when the test flame is applied and causes at least 5 continuous seconds of ignition, may also be determined with this device. This device's temperature range is 120 to 300 degrees.

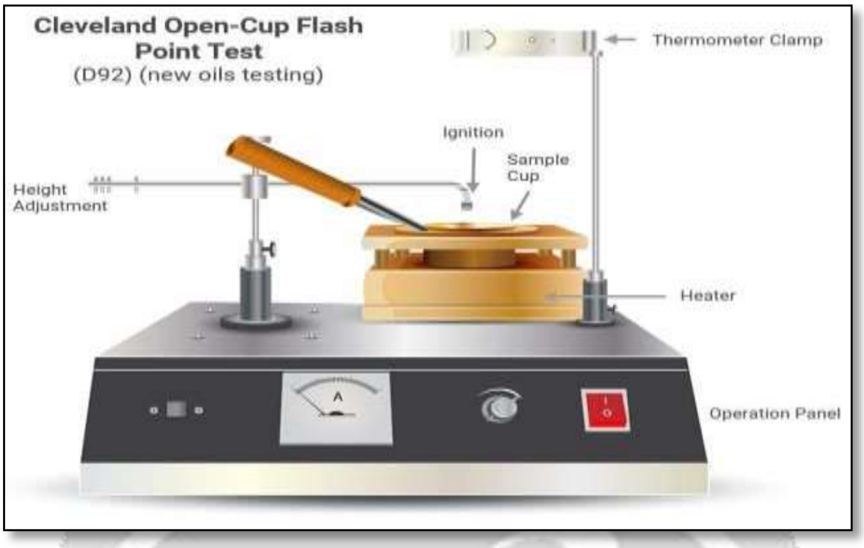

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Fig 3.3 : Cleveland open-cup Apparatus

Redwood viscometer

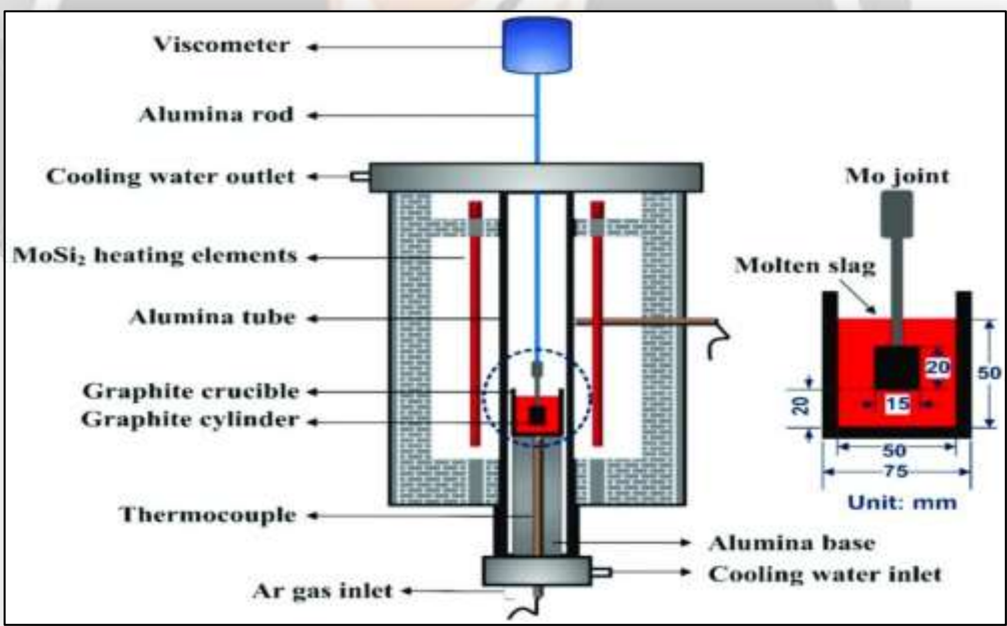

Fig 3.4 : Redwood Viscometer

The viscosity of petroleum products is measured with these viscometers. There are two Red Wood viscometers available: one for liquids with a Red Wood flow time of 30 seconds to 2000 seconds, and the other for liquids with a slide time more than 2000 seconds. Redwood viscosity is measured with a redwood viscometer, which can also convert the results to kinematic viscosity.
It is also used to plot a graph to observe how temperature affects viscosity.

IV. Analysis of the oil sample and its matching bio-lubricant-infused version

Viscosity and viscosity index determination

A liquid's ability to oppose its own flow is one of its properties (the measure of a liquid's flow resistance is its viscosity). Viscosity is measured on the poise scale. It is the most important aspect of any lubricating oil since it serves as the main lubricant. chooses surfaces. On the other side, significant friction happen if the oil's viscosity is more.

Effect of temperature on viscosity: As operating temperature rises, lubricating oil becomes thinner because viscosity of liquids reduces with rising temperature. So that it may be used continuously in a range of temperature-related scenarios, great lubricating oil should have a viscosity that does not considerably fluctuate with temperature change. The viscosity index, an arbitrary scale, is used to measure how rapidly lubricating oil viscosity fluctuates with temperature. If lubricating oil's viscosity rapidly drops when temperature is raised, it has a low viscosity index. On the other hand, lubricating oil has a high viscosity index and better performance characteristics if the viscosity very slightly changes with temperature. If the viscosity of the lubricant is too low, a liquid oil coating between two moving or sliding surfaces cannot be kept in place. Oil's viscosity is a measurement of how resistant it is to progressive deformation caused by tensile or shear stress. With the use of a Redwood viscometer, the kinematic viscosity and viscosity indices of the vegetable oils and their formulated bio-based lubricants were measured and computed [25]. This was done by applying the ASTM D445

- Temperature range of 15 °C to 100 °C.
- Input 230Volt AC, 50Hz, Single Phase, 6 Ampere.
- Current Rated Power Supply.
- 1 Kw of heating load.
- Stirrer: A manual stirrer with a stirrer blade to keep the chamber uniform.
- Stainless steel top lid with provision for mounting one Thermometer.
- The index of viscosity for each oil sample.

Flash and fire point determination

The lubricating oils flash point is the lowest temperature at which it emits enough pors to briefly catch fire when a small flame is brought close to it. The fire point be the lowest temperature at which lubricating oil vapours burn continuously for at least five seconds when a small flame is put nearby. Typically, the fire points are 4 to 40 °C higher than the flash points. Although they have no effect on the oil's capacity to lubricate, flash and fire are important when it is subjected to high temperature service. The flash point of an effective lubricant should be at least higher than the operating temperature. Combustible substances. This protects against the risk of fire while using lubricant. One of the qualities taken into account when determining how flammable a lubricant is is the flashpoint. It could be a sign of extremely flammable and volatile substances.

By using the Cleveland open cup technique according to ASTM D92-12b the flashpoint of each oil sample was identified [25]. 60cc of each oil sample was added to an open test cup that was placed on an authorised hotplate. A thermometer was carefully put into each of the oil samples while gradually changing the heat on the hotplate. A test flame was periodically passed across the open cup holding the samples. The blue flame igniting of the vapour from the oil sample provided the flashpoint value. The flashpoint of each oil sample was tested and recorded.

Blending of Oils

The vegetable oils were measured and mixed in 150ml of lubricant using a magnetic stirrer for 60 minutes at 600 rev/min using beakers.

Tribological and other studies

Both the four-ball tester and the pin-on disk tester were used to measure the tribological qualities of the So that it may be used continuously in a range of temperature related scenarios, great lubricating oil should have a viscosity that does not considerably fluctuate with temperature change. The viscosity index, an arbitrary scale, is used to measure how fast lubricating oil viscosity changes with temperature.

If lubricating oil's viscosity rapidly drops when temperature is raised, it has a low viscosity index. On the other hand, lubricating oil has a high viscosity index and better performance characteristics if the viscosity very slightly changes with temperature. lubricant. According to ASTM D4172 guidelines, the tribological tests were performed using a four-ball tester (Make: DuCom). The steel balls utilized in the trials are AISI 52100 steel balls with a 12.7 mm diameter [21]. The experiment's test parameters included a 396 N load, a 60-minute test period, a 1200 rpm rotating speed. They cleaned the balls. The samples were cleaned with acetone and allowed to dry at room temperature before to the experiments. Three measurements were averaged in order to get the coefficient of friction.

According to ASTM D7279 requirements, the produced vegetable oil-based nano-viscosity lubricants were measured at 30°C,50°C,70°C and 90°C using Redwood viscometers. The Cleveland open cup apparatus was used to gauge the oils' flash point and fire point in accordance with ASTM D92 and D93 standards

The wear scar on the balls was investigated using an image acquisition system in order to understand the wear mechanisms. After the tribo tests, the balls' roughness was measured.

V. Sample Preparation

The dispersion is subjected to Stirrer and mechanical agitation to break down Aggregate particles and disperse them as a uniform suspension. This uniform suspension is used in experimentation for results analysis .In this sample preparation there is concentration of 80% Base oil and 20% Bio lubricant in which the best suited results are taken forward or optimal solution from the above three tests are taken forward for next step of experimentation in which there is addition of additives of which are Silicon dioxide , Graphene oxide and Multi walled carbon nanotubes with their concentration taken from well-known research papers for analysis of next experimentation .

Sample ID	Base Oil	Bio Lubricant	Additives
A	20W40	-	-
B	20W40	Karanja	-
C	20W40	Castor	-
D	20W40	Karanja	SiO_2+GO+MWCNT
E	20W40	Karanja	SiO_2+GO+MWCNT
F	20W40	Karanja	SiO_2+GO+MWCNT

Table 4.1 Sample Preparation

VI. RESULTS

Table 1. Results of all the test.

Sample ID	Lubricant	Scar Area (mm2)			Average Scar Area (mm2)
		Ball1	Ball2	Ball3	
A	20W40	0.161	0.156	0.132	0.1496
B	20W40(80%)+Karnja(20%)	0.054	0.098	0.105	0.0873
C	20W40(80%)+Castor(20%)	0.101	0.089	0.075	0.0889

VII. CONCLUSION

In the present research, properties of lubricating oil 20W40 is evaluated by addition of Bio lubricants such as Karanja oil & Castor oil with SiO2,MWCNT and Go nano particle with various blending combinations of concentrations.

From the results of this present investigation and the discussion presented in the earlier chapters, the following conclusions are drawn. The following conclusions are obtained from experimental results.

1 The tribological test shows that sample B (20W40(80%)+Karanja(20%)) is the best sample among all the prepared samples when compared with Sample A (base oil without additives).

2. Also with that viscosity of Sample B and all the prepared oils is slightly different than original 20W40

3.Wear scar area decreased by almost 50% when blended with the Karanja oil.

From the results of this present investigation and the discussion presented in the earlier chapters, the following conclusions are drawn. The following conclusions are obtained from experimental results.

- The tribological investigation of lubricant oils with nanoparticle additives should show that of SiO2 and GO affect the coefficient of friction and wear scar diameter.
- Higher amount of GO, helps in improving the viscosity, but affects the anti-wear performance.
- This shows that the nanoparticles have the potential of acting as a performance enhancer
- (additive) in the lubricant. So, to achieve better properties determining the appropriate concentration is a very important.

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