

## Analysis of Sodium Greases from Three Recycled Engine Oil

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### Abstract

Grease is a mixture of a fluid lubricant usually petroleum oil and a thickener (soap) dispersed in the oil. The base oil (i.e., petroleum oil) can be substituted with recycled waste lubricating oil. Since the petroleum prices increase yearly, the use of recycled waste lubricating oil as base oil for greases production becomes the best solution to this problem. Sodium soap thickener was formed by reacting sodium hydroxide with palm kernel oil. The production of low-cost sodium grease was achieved. Three different waste lubricating oil samples (150 N, 350 N, 600 N) were recycled and analyzed, to determine the quality of the recycled lubricating oil samples. The results are tabulated. The recycled waste oils were used to produce sodium greases. The produced greases were tested for dropping point (600 N=180, 350 N=160, 150 N=145)°C, worked penetration (180 N=220, 350 N=240, 150 N=300), moisture content (Insignificant), appearance (fibrous and buttery), finger impression (adhesive) and water resistance (susceptible to water). This production was bound by a technology which embraces saponification, evaporation, melting of soap formed and blending with calculated quantity of base oil at the temperature ranging from 170°C to 180°C. The result obtained from the analysis showed that two out of the three products fall within the American Society for Testing of Materials (ASTM) and National Lubricating Grease Institute (NLGI) standard specifications for ball-bearing grease No. 2 and No. 3 respectively. However, the products of this research are economical in terms of cost and availability of raw materials in Nigeria, when compared with imported greases like the Abro-products.

**Keywords:** Blending; Sodium grease; Recycled oil; Base oil

### Introduction

During the usage of lubricating oil, it will age, deteriorate, and lose efficiency due to the mixture with foreign matters that contain metal powder, fillings, and other oils as well as additives. If the lubricating oil is oxidized, its color darkens and the acid value increases to generate precipitate, oil sludge, varnish, and hard varnish. If these materials deposit on the surface and in the low passage and cleaner, it is likely to cause malfunctions of the machine and reduce the overall productive efficiency. At this point, the lubricating oil needs to be changed, to increase the work efficiency, and the replaced oil was waste.

Generally lubricating oil becomes unfit for further use for two main reasons: accumulation of contaminants in the oil and chemical changes in the oil. These effects interfere with the basic properties of lubricating oil which are peculiar for their effective performance during application [1,2].

Man's search for effective lubricating oil is as old as man. The Egyptians in 1400 BC used a mixture of animal fat and calcium soap as a lubricant for their chariot wheels. The Chinese used water as lubricant as early as 3500 BC [3]. Though the fundamental principle of friction and lubrication were discovered by a great scientist, Leonardo da Vinci; wide spread understanding of science of lubrication did not develop until the later part of the 19th century. In 1885, hydrodynamic lubricant was discovered which led to almost immediate development of a theoretical basis for oil film lubrication in 1886. Since then, the applications of lubricants and types of lubricants have been developing rapidly [3,4].

Waste lubricating oils are gotten from different sources, for example from transport sectors (like cars, trucks, etc.) and industrial machines. When oil loses its efficacy and effectiveness during operation because of the contaminations from combustion chambers, metallic particle with water, varnish and gums result in the wearing and tearing of the engine parts [5]. Asphaltic compounds additives, light hydrocarbons, resinous material, mono and poly-aromatic compounds, carbon black in used lubricating oil made it toxic chemical in urban areas at fuel stations and motor repair shops [4,5]. Waste/used lubricating oil causes environmental pollution if improperly disposed because there is a possibility that the substances it may contain if enters the food chain through water, soil and air was toxic to human [6]. The disposal of waste lubricating oil into the seas, rivers and lake environments creates series of problems; in water bodies it does not only contaminate it but harmful to fresh water and marine organisms. One gallon of waste lubricating oil contaminates one million gallons of water [7]. In this manner, used lubricating oil pose risks to human health and impedes the growth of plants and their ability to take-up water since waste lubricating oil contains hydrocarbons, heavy metals, polychlorinated biphenyls (PCBS) and other halogenated compounds, detergents and lubrication additives [8,9]. Waste lubricating oil must be properly disposed else if burnt allows great fuel, harmful metals and other pollutants released into the atmosphere or if dumped into the ground kills the weeds (plants) and if poured on the roads will lead to environmental health problems [10]. In the year 1995, it was found out that less than 45% of used lubricating oil was collected worldwide and the remaining 55% was either misused or improperly disposed by the end users which are severally increasing the problem of waste discharged into the environment [9]. This hazardous waste oil needs proper management to maximize the amount of waste/used lubricating

oil recovery by recycling and to minimize the quantity of oil being improperly disposed in order to reduce the waste oils environmental pollution. This converts harmful wastes into harmless and sustainable substances. This is necessary to increase the collection and re-processing of the waste oil [11]. In the case of re-refining of used lubricating oil, 2.5 quarts of lubricating oil can be produced from one gallon of waste engine oil [12]. The same may be obtained from refining 42 gallons (one barrel) of crude oil processed for fuel containing about 140,000 BTUs [13]. The aim of this research is to know the extent of recycling or treatment of used engine oil using this technique. Specific objectives are (1) to analyses the used oil and characterize the recycled oil, (2) to determine the quality sodium greases which can be produced with the recycled oil.

## Materials and Methods

### Sample collection

Three different samples of lubricating oil of 150 N, 350 N and 600 N base stocks were formulated by Gozie Industries West Africa Venture, Technology Incubation Centre, Federal Ministry of Science and Technology Owerri, Imo State and each was run for two (2) months using an electricity generator. At the expiration of the two months, the oil samples were collected because they were deteriorated.

### Materials and apparatus used

Hydrometer, Viscometer, Beakers, Thermometer, Digital Balance, Toluene Isopropyl Alcohol, Indicator, Oven, Acetic Acid, Sulphuric Acid, Homogenizer, industrial earth.

### Procedure

**Pretreatment:** The collected used engine oil was heated above 150°C to eliminate the water, partly volatile substances contained in the oil. The heated oil could stay overnight (24 hrs) to enable the solid contaminants to settle. The settled oil. was decanted oil and passed through the column of industrial earth. This partly removed some of the heavy metals contained in the used oil.

**Recycling of the used engine oil:** 350 ml of the pretreated used engine oil was measured into a 1000 ml beaker and the beaker was placed on the regulator hot plate as shown in Figure 1. The regulator hot plate was switched on and 35 ml of sulphuric acid was introduced into the pretreated oil simultaneously with stirring of the mixture for 10 minutes (i.e., ratio of 10:1 respectively). The temperature of the used engine oil/sulphuric acid mixture was maintained at 45-50°C. with stirring for 30 minutes to cool and a sediment was formed at the bottom of the beaker. The acidic oil was decanted into another 500 ml beaker and the sludge was kept. The acidity of the oil was neutralized by reacting mixture with 5 wt% of quick lime (CaO) to the oil with continuous stirring for 15 minutes. After that the mixture was allowed to settle for another 5 hours before it was decanted into another beaker (500 ml) (Note: the volume of the mixture was recorded to be 320 ml). Glacial acetic acid was mixed with the oil at the ratio of 1:12.5 respectively (that is, 0.8 ml of the glacial acetic acid to 10 ml of the oil). This was continued with constant and vigorous stirring with the beaker closed (at room temperature and pressure) as shown in Figure 2 for one hour (1 hr). The mixture was left for 24 hours at room temperature and pressure before it underwent centrifugation for one hour to separate the base oil from the contaminants. The separated base oil was then mixed with bleaching earth at a ratio of 1:4 (i.e., 1 mL oil to 4 g

bleaching earth). The bleaching earth was added to remove the dark color and the smell which resulted from the oxidation of some components in the oil. This was achieved by heating to a temperature slightly higher than 250°C, followed by centrifugation for 30 min. This Process produced yellow clear base oil and an amount of sludge very close to the initial weight of the bleaching earth used plus 5 wt%.

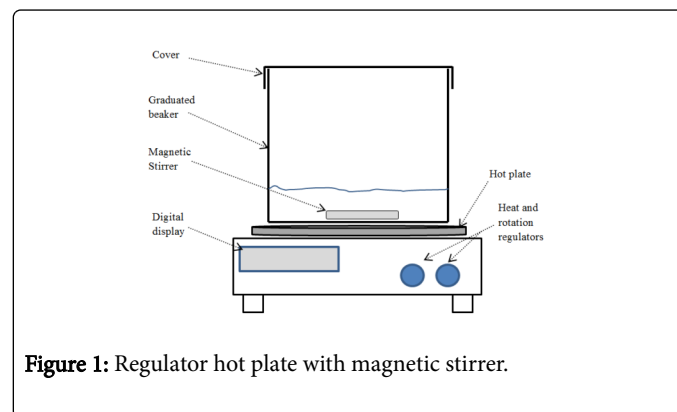


Figure 1: Regulator hot plate with magnetic stirrer.

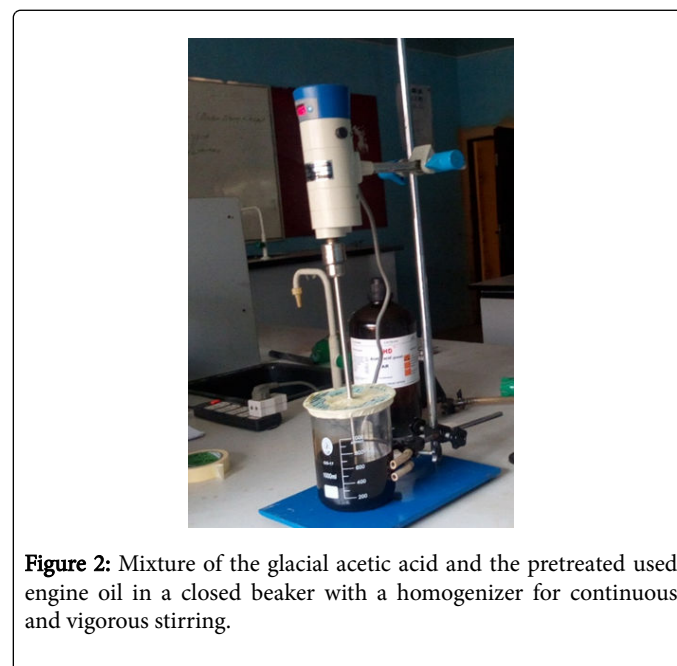


Figure 2: Mixture of the glacial acetic acid and the pretreated used engine oil in a closed beaker with a homogenizer for continuous and vigorous stirring.

### Characterization of recycled and fresh oil sample

The Recycled and fresh oil samples were collected with clean beakers and were ultimately analyzed for characterization. The following standard methods of characterizations were carried out using standard methods of testing as recommended by ASTM (Annual book of ASTM, 1987, ASTM test method).

**Density:** A random volume of the oil sample was put into graduated cylinder and a density measuring device (hydrometer) was simply inserted at the top. While the device is floating, the point where the meniscus of the oil coincides is read on the hydrometer as the density of the oil.

Density of the oil is influenced by the chemical composition of the oil. For example, used engine oils density increases with the presence

of increasing amounts of contaminants. One percent of weight of solids in the sample can raise the specific gravity by 0.007 g/ml [13].

**Viscosity:** Kinematic viscosities of the oil at 40°C and 100°C are usually used to characterize the oil quality. Dynamic/kinematic viscosity at 40°C was measured using digital viscometer at which the viscosity was directly read from the display of the apparatus. Since the maximum temperature using the viscometer is 60°C, the falling ball method was used to determine the dynamic viscosity at 100°C. In this method, the oil sample was poured into a graduated tube channel and the ball dropped into the oil, the time taken by the ball to fall from the top to the bottom was recorded. Eqn 1 was used to calculate the viscosity using the time data.

Finally, the kinematic viscosity was obtained by dividing the dynamic viscosity with the respective density of the oil.

$$\eta = K(\rho_b - \rho)t \quad (1)$$

Where;  $\mu$ =viscosity (cp);  $\rho_b$ =density of ball (8.53 g/ml);  $\rho$ =density of liquid;  $t$ =time of descent (sec);  $K$ =viscometer constant (1.238).

**Viscosity index:** The viscosity index is used to determine how much particular oil's viscosity changes with temperature. It is a method of applying a number to this rate of change based on a comparison with two arbitrary selected oils. The reference oils have been selected in such a way that one of them has the viscosity index which is equal to zero (VI=0) and the other has the viscosity index equal to one hundred (VI=100) at 37.8°C but they both have the same viscosity as the oil of interest at 98.89°C.

Viscosity Index is calculated using the following formula:

$$VI = \frac{(L - U)}{(L - H)} \times 100 \quad (2)$$

Firstly, the kinematic viscosity of the oil of interest was measured at 40°C (U) and at 100°C. Then from the viscosity index table, the viscosity at 100°C of the oil of interest and the corresponding values of the reference oils, 'L' and 'H' respectively were read. Substituting the obtained values of 'U', 'L' and 'H' into the above equation yielded the viscosity index.

**Flash point:** The flash point of the oil was determined by heating the oil at standard pressure to a temperature which was just high enough to produce sufficient vapor to form an ignitable mixture with air. The test specimen was put in an open cup and its temperature was gradually increased by heating and being monitored using a thermometer. At specified intervals a test flame is passed across the cup until the vapor of the test specimen of the sample ignites. The temperature at which a spark of fire is observed was recorded as the flash point.

**Neutralization number/Total acid number (TAN):** The Neutralization Number or Total Acid Number (TAN) of the oil was conducted using ASTM D974. It is the quantity in milligrams of potassium hydroxide (KOH) per gram of oil necessary to neutralize acid. Two grams of the oil sample was weighed and mixed with 100 mL of the titration solvent (toluene and isopropyl alcohol containing a small amount of water) and 0.5 mL of the indicator solution (p-naphtholbenzein) and swirled until the sample was entirely dissolved by the solvent. The mixture turns into a yellow-orange colour and it was titrated with 0.1 M KOH solution in increments and mixed vigorously near the end point i.e., green colour. To observe the end point of dark-colored oil, the flask is shaken vigorously to produce

momentarily a slight foam and the colour change occurs under a white fluorescent. The neutralization number or Total Acid Number (TAN) is calculated as;

$$TAN = \left( \frac{mgKOH}{g \text{ sample}} \right) = \frac{[(A - B) \times M \times 56]}{W} \quad (3)$$

Where; A=KOH solution required for titration of the sample, mL,

B=KOH solution required for titration of the blank, mL,

M=Molarity of the KOH solution, and

W=Sample used, g.

**%Water Content:** The water content is estimated by weighing and putting a measured amount of sample in an oven at 120°C for an hour. The dehydrated sample is then weighed to calculate the loss.

$$\%Water = \frac{M \text{ initial sample} - M \text{ final}}{M \text{ initial}} \times 100 \quad (4)$$

**Metal content:** The metallic content analysis was performed using a fast-sequential atomic absorption spectrometer. Before the analysis the engine oil sample was heated to 60°C and stirred to ensure homogeneity of the sample and also mixed with ten volumes of kerosene. Sets of organometallic standards of metal (Cu, Fe, Pb etc.) 4-cyclohexylbutyric acid salts were prepared and metal concentrations were determined by introducing the test solutions of the oil samples into the flame of the atomic absorption spectrophotometer and recording the responses. Metal concentrations were determined from the calibration curve that was obtained from standard solutions. Standard solutions for all metals in engine oil samples were prepared according to ASTM D 4628-2.

### Lubricating grease production

Grease=Base Oil+Thickener+Additives and Modifiers

- Base Oils (recycled oils)

(i) 150 N

(ii) 350 N

(iii) 600 N

N=Neutral base oil

- Thickeners(Na-soap)

Soap=Metallic Hydroxide(NaOH)+Fatty Material (PKO)

### Preparation of sodium hydroxides (NaOH)

50% each of the Sodium hydroxide solution was prepared by dissolving one kilogram (1 kg) in say 2 litres of water. The concentrated solution was allowed to stay for 24 hours (one day) to cool to room temperature of about (30°C). At this point, it was diluted further by adding known volume of water at intervals and stirred to form a homogeneous solution. The Sodium hydroxide solution prepared was used for production of sodium soap based on the saponification value of the PKO (palm kernel oil) used. The saponification value of the palm kernel oil (PKO) used in this case was 232.1 mg NaOH/g oil. The reaction between the Sodium hydroxide and the fatty material (PKO) to form Sodium soap is called Saponification. Hence soap was prepared by reacting a measured quantity of metallic hydroxides solution and a measured quantity of vegetable oil like palm kernel oil (PKO), by the ratio of 1:2 (metallic hydroxides solution (1): vegetable

oil (2)) based on their saponification values at the specific gravity of 1.275 for caustic soda at room temperature of 30°C.

### Production of lubricating grease (Na- Grease)

103 grams of the Sodium hydroxide solution prepared by dilution of the 50% solution to a concentration of 26% at room temperature was weighed into the metal container (Reactor) containing the palm kernel oil (PKO) which was heated to a temperature of 60°C (Saponification temperature) based on the Saponification Value of the palm kernel oil. The weighed metallic hydroxide was gradually added into the reactor. The mixture of the two components was stirred for a period of (5) minutes depending on the volume of the reactants (fatty matter and metallic hydroxide solution) to saponify and form soap. The soap formed in the process was later heated up to a temperature of about (120°C to 130°C) at atmospheric pressure in order to remove the water formed (by evaporation). That was the temperature at complete saponification, and the soap obtained at this stage was very thick and in a solid state.

After saponification and evaporation at about 130°C, little quantity of the base oil was added to the soap formed and heated to a temperature of about 170°C to 180°C to melt. The addition of the base oil depends on the mass of the soap formed and it is to reduce friction and ease the stirring. At the above specified temperature, the thickened soap melted to a liquid state and becomes gummy or sticky on little exposure to air. At this temperature (180°C) the soap was dispersed in the base oil (recycled oil) by gradual addition and stirring until the grease is formed. Here, reasonable quantity of base oil was added in the respective production made.

**Note:** The total volume of base oil to be added per batch depends on the texture of the product sample on cooling to room temperature: say 30°C.

However, before allowing the grease to cool to room temperature, milling/blending operation was performed using locally fabricated grinder at the temperature of 80°C. Milling is a form of homogenizing. This method will help in reducing the particle size of the non-dispersed thickener in the base oil.

### Analysis of the produced greases

A total of three (3) samples of grease were analyzed for the following characteristics below:

**Worked penetration (ASTM D92 2012):** Worked penetration is the penetration of a sample of lubricating grease after it has been brought to 25°C (77°F) and then subjected to 60 double strokes in a standard grease worker and penetrated without delay. Worked penetration is used to establish the consistency of lubricating grease within the NLGI consistency grades. The change in worked penetration results of a grease after a prolonged working is believed to be a measure of its shear stability, under the conditions of the test. Penetrometer is used for the test. Penetrometer is an instrument designed to measure in tenths of a millimeter of the depth to which the standard cone penetrates the grease.

**Procedure:** Sufficient sample (at least 40 grams) of grease was cooled to 25°C and later transferred into the grease worker cup. The grease cup was Jared sharply on the bench or floor to remove the air pockets. The grease cup was finally filled.

### Dropping point of lubricating grease (ASTM D445-97 2000)

The ASTM - dropping point is the temperature at which a conventional soap-thickened grease passes from a semi-solid to a liquid state under the conditions of test or it can be the temperature at which certain other non-soap-thickened greases rapidly separate from the oil. ASTM-Dropping point method is useful in identifying the grease type and for establishing and maintaining standards for quality control.

The apparatus consists of small chromium plated brass cup of specified dimensions shown in Figure 3, a heat-resistant glass test tube provided with three indentations equally spaced on the circumference, a thermometer with ranges of -5 to 300°C, a heating bath and an oil bath. The oil for an oil bath must have a flash point in excess of the maximum temperature at which the bath is to be used.

**Procedure:** The grease sample is placed in the cup and a cone-shaped space created by means of a rod manipulated through the orifice. A thermometer occupies the space out of contact with the grease. The heating takes place at specified rate and the temperature at which oil falls or drops through the orifice of the cup to the bottom of the test tube was noted. The operation was repeated as a check or for consistency of the result, and the average reading was determined and recorded.

### Moisture content of produced grease: Dean and stark apparatus

The standard method of test used for moisture content is ASTM D95 2012. The Dean and Stark Apparatus was used. The grease sample was heated under reflux with (xylene solvent) water-immiscible solvent which co-distills with water in the sample. Condensed solvent and water were continuously separated in a trap, the water settling in the graduated section of the trap and the solvent returning to the steel. The difference in the level of water initially in the trap and that after boiling the sample is normally read from the demarcation. Hence water and xylene solution does not mix. The difference in the initial level of water in the trap or graduated tube will give the amount of water in the grease which was very negligible.

## Results and Discussion

### Characterization of recycled base oil

Looking at the results obtained from the analysis of the recycled oil which is contained in Table 1, it fully describes its properties. Flash point, viscosities at 100°C and 50°C, viscosity index, neutralization number or total acid number (TAN) were the characteristics tested. This characterization helps to explain the quality improvement of the recovered or recycled base oil as compared to the properties of the fresh oil sample (Table 1).

The flash point of the recycled oil is slightly lower than that of the fresh oil. The decrease in value of the flash point of the recycled oil could be as a result of the presence of light ends of oils. In essence, if the oil after undergoing combustion and oxidation at high temperature of the combustion engine, the oil breaks down into component parts, which include some light ends. This decrease in flash point of the recycled oil may be also be as a result of fuel dilution for an engine that has bad piston rings. The flash point has greatly improved after recycling the oil but not as well as that of the fresh oil.



Nevertheless, the flash point is within the acceptable ranging according to the ASTM D4304 reference standard (that is it should be greater than 180°C) [14]. The viscosities of the recovered oil at 50°C and 100°C are lower than that of fresh oil.

Parameters	Engine oil					
	150 N		350 N		600 N	
	RF	RR	RF	RR	RF	RR
Density g/ml(ASTM D4052 and D1298)	0.874	0.875	0.835	0.882	0.885	0.888
Viscosity@50°C mm <sup>2</sup> /sec (ASTM D445/IP71)	20	19	43	39	67	62
Viscosity@100°C mm <sup>2</sup> /sec (ASTM D445/IP71)	-	11	-	26	-	40
Flash Point (OC or OF)(ASTM D92)	200	215	215	245	240	255
Neutralization number (ASTM D664, D974)	0.05	0.03	0.05	0.05	0.05	0.05
Ash wt%	0	0	0	0	0	0
Pour Point OC (ASTM D97)	-15	-9	-9	-12	-9	-12
Ash Content (wt %)	0	0	0	0	0	0
Moisture Content (%)	Nil	Nil	Nil	Nil	Nil	Nil

RF=Refined fresh, RR=Recycled

**Table 1:** Result of the Quality Comparison of Refined Fresh Base Oils and Recycled used Engine Oil.

This may be as a result that the recycled oil lost most of its viscosity due to contamination. Hence the treatment has remarkably reduced the viscosity indicating the removal of contaminants in the recycled oil. In the same manner, addition of viscosity improvers may also give better qualities to the recovered oil.

The density of the recycled oil is always higher than that of fresh oil. The densities for the fresh and recycled oil samples are (150 N=0.875; 350 N=0.835 N; 600 N=0.895) g/ml and (150 N=0.874; 350 N=0.882; 600 N=0.888) g/ml respectively. This may be that the treatment and recycling of the oil has restored the oil density similar to that of the fresh oil.

In Table 1, the neutralization number or Total Acid Number (TAN) of the recycled oil is found to be (150 N=0.03; 350 N=0.05; and 600 N=0.05) mg KOH/g. This can be concluded that the treatment has contributed in reducing the TAN of recycled oil which may initially measure to be higher. This may be due to the possible presence of organic, inorganic, heavy metal salts, resin water and corrosion materials which result from the oxidation process that occurred at elevated temperatures in the engine [13].

The water content in the recycled oil sample is found to be insignificant (IS) which means that after recycling, the water was drastically reduced. This may be as a result of the pretreatment (heating) and other evaporation or open distillation processes during the recycling.

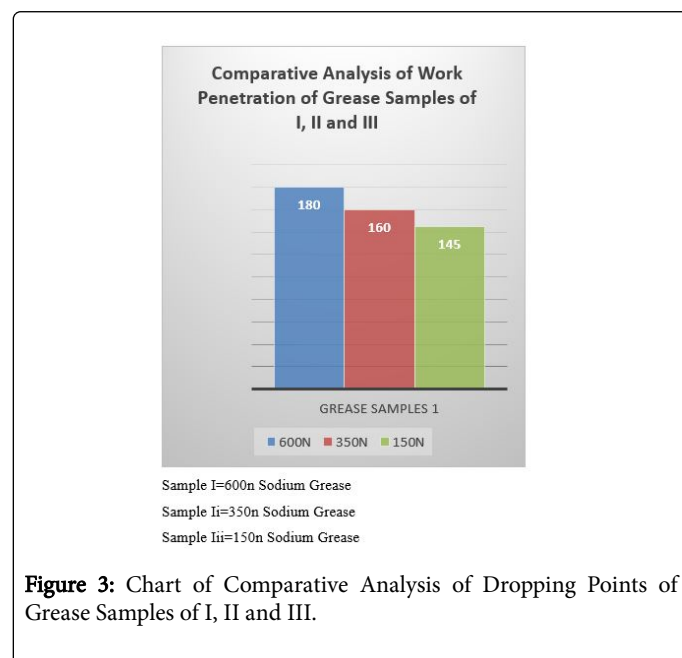
### Analysis results of produced sodium grease

From the above Table 2 and Figure 3, it is observed that the dropping point of sodium-based grease increases from 150 N through 350 N to 600 N (145, 160 and 180°C respectively). Dropping point is the temperature in °C or in °F at which a conventional soap-thickened grease passes from semi-solid state to liquid state under the conditions of test. It can also be temperature at which certain non-soap thickened grease separate rapidly from oil. Sodium greases have relatively high dropping point of the range 175°C-330°C which is the highest amongst the simple soap greases. From the Table 2, it is only the grease of 600 N that falls within the range. This may be as a result of the low viscosity in 150 N and 350 N during the recycling process of the base oil samples. It was noted that during the removal of the contaminants during the recycling, the viscosity of the oil got reduced.

Parameters	Base oils used for the sodium (Na) grease		
	600 N	350 N	150 N
Dropping point (°C)	180	160	145
Worked penetration	220	240	300
Moisture	IS	IS	IS
Appearance	Fibrous or buttery	Fibrous	Fibrous
Finger impression	Adhesive	Adhesive	Adhesive
Water resistance	SS	SS	SS

IS=Insignificant; SS=Susceptible

**Table 2:** Result of Sodium (Na) Grease Analysis.



**Figure 3:** Chart of Comparative Analysis of Dropping Points of Grease Samples of I, II and III.

From the same Table 2 and Figure 3, the worked penetration of the sodium-based greases decreased from 150 N through 350 N to 600 N as 300, 240 and 220 respectively. This property is a measure of the consistency of the greased under pressure.

There is insignificant amount of water in sodium greases. This may be as a result of evaporation of the formed water during heating of the soap and oil mixture above the boiling point of water. Sodium based grease is fibrous in appearance. This is as a result of the residual moisture formed during the process of production especially those made from animal or vegetable fat which are triglycerides. The glycerol by-product of the soap making act as stabilizer for the fibrous structure of the grease. This impairs the grease oxidation stability.

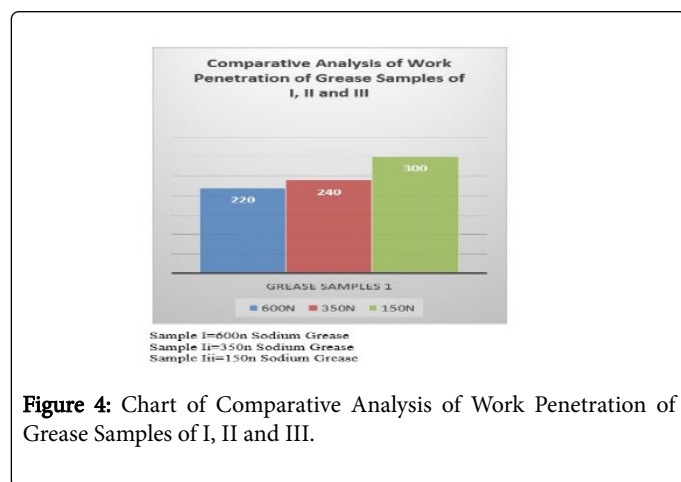


Figure 4: Chart of Comparative Analysis of Work Penetration of Grease Samples of I, II and III.

The greases are adhesive to the finger when finger impression test is conducted. Sodium based grease produced with the recycled oil is susceptible to water. Its water resistance property is poor like other sodium-based greases [15-17]. This test shows the extent of water wash-out of the grease. It can be improved by adding a water-resistant grease like Ca, Ba, Polymer greases etc. to it. However, when used in completely anhydrous environments, sodium soap greases perform well even at a temperature of 150°C which is substantially higher than the temperature that most simple soap and some complex soap greases can withstand.

## Conclusion

This study proved that recycled oil can be used to produce lubricating grease. The recycled oil as a comparable quality with the fresh oil indicates that it can possibly be re-used. The same thing happens in the lubricating greases produced with the same recycled oil. The lubricating grease properties were determined using the standard chemical and physical tests.

Based on the results obtained from this research work, it would be clearly and precisely stated that the sodium grease produced from the recycled oil is ideally a high-quality product suitable for ball bearing based on ASTM/NLGI consistency grading. Based on the analysis carried out (Tables 1 and 2; Figures 3 and 4) and the results obtained, the following conclusions therefore holds that:

- Sodium grease could be prepared by dispersing sodium soap in (either 650 N, or 350 N or 150 N) recycled base oil. It was carried out by a technology bounded by saponification, evaporation, melting of thickened soap mass (at the temperature of about 170°C to 180°C), and blending of the melted soap with base oil. Samples of the products produced in this research were labeled Samples I, II and III. Where I represent 600 N greases of sodium. Sample II represents 350 N greases of sodium. Finally, sample III represents 150 N greases of sodium.

- From, Figure 3, Sample I have a dropping point of 180°C. This show the effect of dispersion of a thickener in high density base oil like 600 N or Bright stock. The dropping point of Sample II was lower than that of sample I. Generally, all sodium greases belong to the class called thick grease.
- From Figure 4, sample I and II fall within the worked penetration ranges of 220 to 250, which indicates that the grease sample I and II, were thick and they lie within No. 3 of ASTM/NLGI consistency grade. While for Sample III, worked penetration lies between N LGI consistency grade 1 and NLGI grade 2. From the value, it is closer to grade 2 which also indicates that the grease was soft. It could be stated here that the consistency number varies with worked penetration. On the other hand, the lower the worked penetration value, implies that the grease sample was thick, and the consistency value/number in this case goes higher.

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