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Effect of Sodium Hydroxide Thickener on Grease Production

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Authors' contributions

This work was carried out in collaboration between all authors. Authors HMK and MNA designed the study. Authors KE, MNA and BEAD performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KE and BEAD managed the analyses of the study. Authors KE and SOOO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Sodium hydroxide (NaOH) was used to produce grease from spent engine oil. A study of the unworked penetration, viscosity, and dropping point of the grease were analyzed under different temperature ranges, from 30℃ to 60℃.

The grease produced was of Brown colour on physical observation. The viscosity decreased at increased temperature with its minimum viscosity being 340.2 and maximum viscosity 590.0. The penetration point also increase as temperature increased and the minimum penetration was found to be 255.0 (in 10^{-1} mm) and maximum penetration was 415.2 (in 10^{-1} mm). The dropping point test showed an increase with increase in temperature. The minimum dropping point was 177.4℃ while the maximum dropping point was 239.3℃. An increase of temperature up to 40℃ shows the consistency number for the grease to be within most commercially available grease grade i.e. within grade 2 and 3 in the market, hence, the grease produced shows good quality for application within working temperature of between 30℃ and 40° C.

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1. INTRODUCTION

Complex mixtures of hydrocarbon molecules are vital components of lubricating oils from petroleum. The composition of the lubricating oil includes slightly longer branches of isoalkanes and several short branches on the ring which is from monoaromatics and monocycloalkanes [1,2]. The viscosity oils of these hydrocarbon molecules range from low to very viscous lubricants having molecular weights to be as low as 250 and high as 1000 respectively [3]. The range of the carbon atoms is from 20 – 34.

Environmentalist believes that there is a risk of a high hazardous potential as a result of used engine oil. Major amounts of water bodies, e.g. ground water, can be polluted by a small amount of pure oil and also additives, impurities and residues of contaminants during combustion process leading to used engine oil. Pb (Lead) or PAH (poly-aromatic hydrocarbons) are some of the poisonous and carcinogenic substances, also a highly carcinogenic substance i.e. PCBs (polychlorinated biphenyls) are sometimes present in transformer oil [1].

Lubricating oils from motor vehicles, combustion engines and gear boxes are by far the largest source for used oil in developing countries. Small amount of other sources of used oil come from hydraulic systems, transformers and other varying industrials applications. The amount of used oils from motor vehicles in the past in developing countries continues to increase as a result of the increase of automotive traffic. Garages, small workshops and private premises are some of the great number of places where majority of used engine oils are generated in small quantities [4]. The railways, large truck fleet operators and large industries are a few waste oil generators.

Engine oil loses its potency when the additives in it become inactive [5]. Carbon from wears causes the colour from the used oil to be dark [6]. Engine oil colour is being maintained by the acid present in it whereas neutralization of a base weakens the acid in used oil [6]. Recycled engine oil has additives incorporated in it and sometimes mixed with virgin oil [7]. For the engine oil to be used again, recycling processes are used for the treatment.

One simple method to make use of waste engine oil is the production of grease. Production of grease involves the mixing of spent oil with warm soap which is freshly made in a composition of 20% soap to 80% waste oil. A typical greasy consistency is formed after the mixture has been stirred for sometimes [4]. The final grease viscosity is determined by the amount of oil introduced. The final grease is of a minor quality which is as a result of minor quality of oil introduced but it can still serve its purpose for many low scale applications.

Grease, which is semi-solid in nature, belongs to the group of lubricating oil and it is used for lubricating moving parts of engines and machines. Lubricating greases, industrial lubricating oil and automotive oils are the three major classes of lubricating oils.

The motion of connected parts is easily enhanced when lubricating oils are used in service and this oil help in protecting rubbing surfaces [8], Hence, aiding the removal of a high build up temperature on the moving surface. Properties like viscosity, specific properties e.t.c reduces if the temperature build up continues. Deposits of dirt and metal parts worn out from surfaces are present in the lubricating oils. Over-reduction of desired properties in the lubricating oil results from its prolong usage [8], which must be replaced by a virgin one after the former have been removed. The disposal of lubricating oils is now a major problem due to the large amount of engine oil usage. The problems associated with environmental pollution posed by waste or used lubricating oils in many countries are now being addressed [9]. The USA for example generates annually about 2 billion gallons of oil [10]. Environmentally friendly lubricant from natural resources is expected to increase in the next century [11].

Governments and industries have found solutions that will satisfactorily reduce used lubricating oil contribution to pollution and the recovery of these valuable hydrocarbon resources [12]. Dust prevention also called dust cure is one of the ways of disposing used oil [13]. This is an unsatisfactory way of disposing used oil as air and water pollution are the result of lead-bearing dust and run-off. Another disposal method of the used oil is by incineration. The poor use of this method for the used oil and the possibility of a carcinogens emission contribute to environmental pollution [14]. Environment concern and the fear of dwindling of world oil reserves have led to more attention been given to the recycling of used lubricants.

Consistency is a measure of the stiffness of grease. A proper consistency will make the grease stay in the bearing (its area of application) without generating too much friction. It is classified according to a scale developed by the NLGI (National Lubricating Grease Institute). Grease for bearings are typically NLGI 1, 2 or 3. The test measures how deep a cone falls into a grease sample in tenths of mm.

The firmness of grease tells more about the consistency of the grease. The area of application of grease is determined by its design and formulation. Lubricating grease finds application is so many areas especially in machinery and moving part to improve its efficiency and prolong its life-time [15]. The consistencies of the grease properties and structure span from semi fluid to nearly solid. The harness of the grease is a function of weather it may not flow satisfactorily to the areas in need of lubrication (i.e. too hard) or may leak out from the desire area (i.e. too soft). The penetration of grease by penetrometer is proportional to the composition of grease as described by the un-worked penetration test (i.e. Table 4). Increasing the amount of the Spent Bleaching Earth (SPE), results in the reduction of the penetration and likewise the NLGI grade obtained. During operations, grease can flow easily i.e. a lower consistency of the grease is indicated. Grade 2 and 3 are the common grease consistency for most marketable lubricating grease. The consistency of grease confirms the penetration test.

The thickener in producing grease is non-soluble and there is no major effect when heat is applied and pro-longed mixing time on grease homogenization. As pressure and temperature are been increased, Spent Bleaching Earth which acts as a reservoir for base oil absorbs and releases the oil. The un-worked penetration does not actually propose the grease real operation. It is observed that the penetration value for normal room temperature is different from elevated temperature. Reading should be taken at room temperature which is 25℃ based on the ASTM standard method [16].

Since the 1930s, used lubricants recycling has been practiced especially during the Second World War conflict when crude oil supplies became scarce and this in-turn encouraged all types of materials including lubricants to be reused [17]. Presently, environmental concerns involving interest in the concept of recycling as regard to the conservation of resources has been maintained [1]. In some countries, the reclamation of spent crankcase oils is a pressing national interest issue. On the other hand, it is recognized that pollution of all oil spills at sea and offshore put together is smaller when compared with that of used lubrication. With petroleum storage in countries, spent oils which is a precious commodity is not allowed to waste. For this reason did the conservation of petroleum resources declare a national policy in several countries; the benefit of wise resource management is evident [18].

There is a renewed drive towards waste to recover and convert into useful original lubricating oils the used lubricating oil.

Table 1. NLGI consistency number classification of greases

NLGI number	ASTM worked penetration (10^{-1} mm)	Appearance (25℃)
000	445 – 475	Very unsolidified
00	400 – 430	Unsolidified
0	355 – 385	Semi – unsolidified
1	310 – 340	Very soft
2	265 – 295	Soft
3	220 – 250	Medium solid
4	175 – 250	Solid
5	130 – 160	Very solid
6	85 – 115	Extremely solid

2. MATERIALS AND METHODS

2.1 Materials

The materials needed for this work include; Beaker, Measuring cylinder, Bunsen burner, Thermometer, Universal indicator, Viscometer, Buckel, Hydrometer, Volumetric flask, Mesh, Cooking pots, Conical flask, Stop watch, Cylindrical bottle, Used engine oil, Fine particle sand, White cloth of size 100 microns, Sodium hydroxide (NaOH), Concentrated sulphuric acid (H_2SO_4), Local palm oil and Distilled water.

2.2 Methods

A thick and dark used engine oil sample which is due to carbon from wears and the weakened acid as a result of neutralization by a base [6] was collected from a car which is about to be serviced after its engine have worked 3500 rpm from when it was last serviced with a high performance multi-grade engine oil (i.e. SAE

20W/50, API SJ/ CF-4) from a local filling station at Yola. Its pH (using a pH meter), viscosity (using viscometer) and specific gravity (using hydrometer) were determined.

Fine particle sand were arranged in a cylindrical bottle and the used engine oil was allowed to run through the sand particle bed so as to collect any metallic filling present in it. After which it was allowed to flow through the piece of cloth covered over a beaker for further separation. Two litre of the filtered spent engine oil was mixed with 30 ml of concentrated sulphuric acid and heated at 60℃ for 900 s.

The mixture was left to cool for 14400 s. The coagulate settles at the bottom of the container and the sludge decanted. The sample collected was mixed with 40 ml of concentrated H_2SO_4 for further purification, then the sludge decanted. Further purification of the sample was with 50ml conc. H_2SO_4 and the sludge decanted. The pH of the dislodged engine oil is raised to neutral (pH 7) by using an alkaline medium.

The base thickening agents were prepared by preparing 1 M concentration of aqueous sodium hydroxide and mixed thoroughly with 200 g of palm oil. Heat was applied at 85℃ with constant stirring and cooled. Different proportions of the thickening agents as well as an additive were blended with different proportions of dislodged/ treated engine oil. The resultant blends (grease) were subjected to viscosity test, penetration test and dropping point test using ASTM standard D2422, D217, D-566 respectively.

3. RESULTS AND DISCUSSION

3.1 Results

Table 2 shows mainly some properties of spent engine oil. The specific gravity determined at room temperature was 0.880. The pH determined was 6.23 indicating that the spent engine oil was lowly acidic. The viscosity of spent engine oil was determined to be 156 centipoise. Fig. 1 is a schematic representation of the grease production.

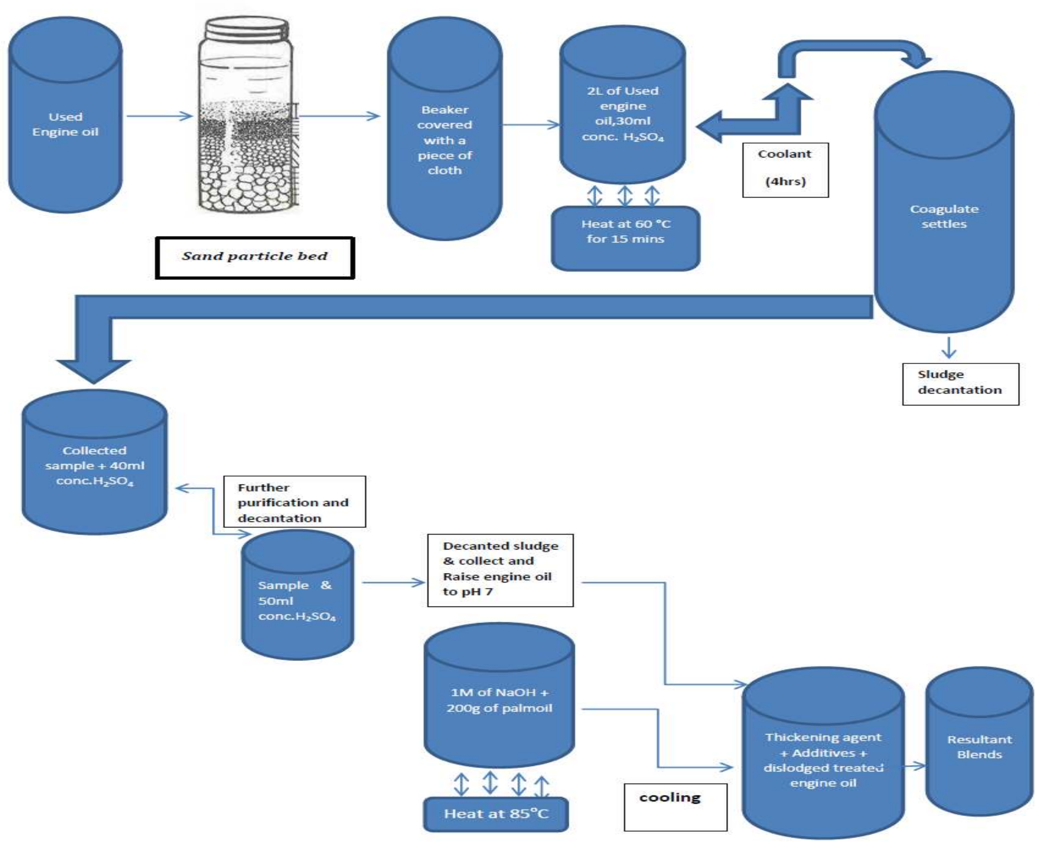

Fig. 1. Schematics for grease production

Viscosity is defined as the internal resistance of a fluid to flow. The viscosity of a lubricant changes with temperature, in almost all cases, as the temperature increases, the viscosity decreases; conversely, as the temperature decreases, the viscosity increases [19]. Figs. 2 and 3 show similar trend as reported [19], where the five formulated grease drop in viscosity as test temperature increased from 30℃, through 40℃, 50℃ to 60℃. This makes the grease which was semi – solid to become liquid, hence their viscosity decreased.

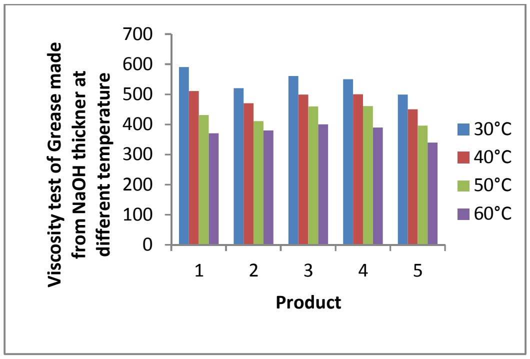

Fig. 2. Viscosity test for grease produced from sodium hydroxide thickener

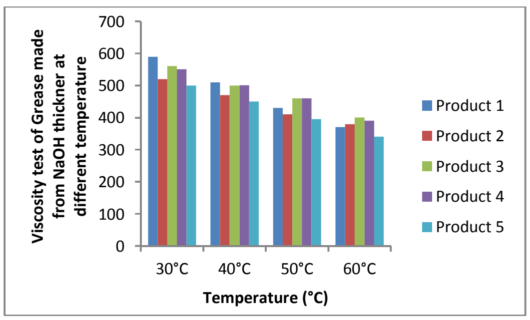

Fig. 3. Comparative viscosity test of 5 grease products from sodium hydroxide at different temperature

Grease penetration is the depth in which a cone sinks into the grease in pre-specified conditions. The deeper the cone is into the sample, the higher will be the penetration number and the grease will be softer. This can be observed in Fig. 4 and Fig. 5 when the test temperature was increased from 30℃, through 40℃, 50℃ to 60℃, the formulated grease produced was lowly viscous i.e. lost its consistency thereby softening. This allowed the cone to go deeper and easily into the various grease samples, hence, having higher penetration number.

The formulated grease's consistency is determined by measuring the penetration of cone into the grease by penetrometer and comparing the result to the standard established by National Grease Institute (NLGI) as shown in Table 1. The formulation of the products is based on Table 3. Comparing the worked penetration results obtained for the grease produced with the penetration method used by the NLGI, the consistency shows products 1, 2, 3, 4, and 5 to have a consistency number within the range 2 and 3 with appearance of medium and medium hard at a temperature of 30℃ while with temperature increase to 40℃, the unworked penetration for the five products increased having its consistency number around 1 and 2 with their appearance at soft and medium (see Table 4). This implies that these grease can function well for bearing especially at temperatures of 30℃ and 40℃ and it agrees with the report that the common grease consistency for most of the commercial lubricating grease lies within grade 2 and 3 [16]. A consistency number of 0 (semi-fluid in nature) was attained during the unworked penetration of the formulated grease as the temperature is increased to both 50℃ and 60℃.

Dropping point is the temperature at which grease passes from a semi – solid to a liquid state under the conditions of the test. At the test conditions of 30℃, 40℃, 50℃ and 60℃, for the five grease formulated products, the grease loses its resistant to heat as the temperature increases thereby protruding slowly through the orifice of the cup. This is shown in Figs. 6 and 7.

Table 2. Properties of spent engine oil

S/N	Description	Value
1	Specific gravity Spent engine oil	0.880
2	pH of spent engine oil	6.23
3	Viscosity of spent engine oil	156 centipoise

Table 3. Ratio of the blend for the formulated Grease

Formulation number of product	Ratio of NaOH	Ratio of palm oil (PO)	Ratio of Spent engine oil (SPE)
1	3.5	1.0	2.7
2	3.5	1.0	2.1
3	3.5	1.0	2.4
4	3.3	1.0	3.3
5	3.5	1.0	2.4

Table 4. NLGL grade for formulated grease

Grease formulation	Comparative hardness grade @ 30℃		Comparative hardness grade @ 40℃		Comparative hardness grade @ 50℃		Comparative hardness grade @ 60℃	
	Unworked penetration	**NLGI consistency number**	**Unworked penetration**	**NLGI consistency number**	**Unworked penetration**	**NLGI consistency number**	**Unworked penetration**	**NLGI consistency number**
Product 1	265.0	2	320.0	1	355.0	0	395.5	00 - 0
Product 2	260.8	2 – 3	330.1	1	365.2	0	410.0	00
Product 3	267.2	2	340.1	1	369.3	0	415.2	00
Product 4	255.0	2 – 3	302.4	1 – 2	355.5	0	374.5	0
Product 5	255.2	2 – 3	306.3	1 – 2	354.9	0	372.5	0

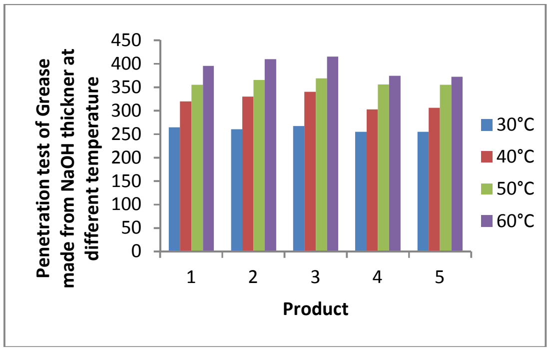

Fig. 4. Penetration test for grease produced from sodium hydroxide thickener

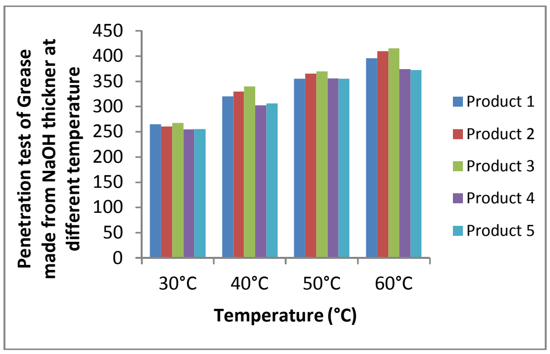

Fig. 5. Comparative Penetration test of 5 grease products from sodium hydroxide at different temperature

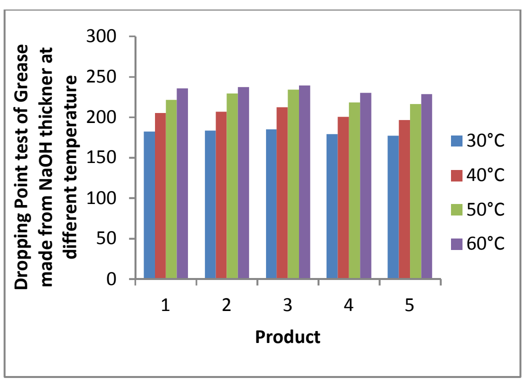

Fig. 6. Dropping point test for grease produced from sodium hydroxide thickener

Dropping point using sodium hydroxide as a thickener was around 170℃ – 190℃ which have the characteristic properties of a good high temperature use and good shear stability, fibrous in structure and can be poorly resistant to water [20]. Likewise the five products of grease produced from sodium hydroxide as thickener had its dropping point value when studied at 30℃ (i.e. Fig. 6 and Fig. 7) to fall in the range of 177.4℃ – 182.4℃, hence could exhibit the same property as above.

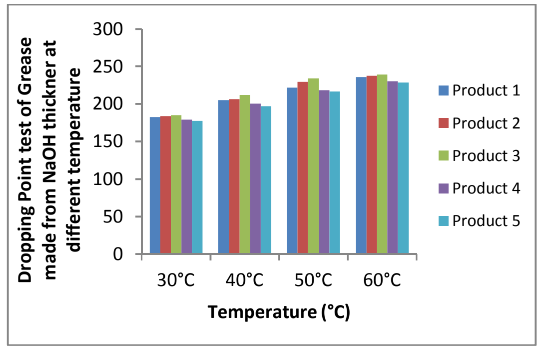

Fig. 7. Comparative dropping point test of 5 grease products from sodium hydroxide at different temperature

4. CONCLUSION

The spent engine oil ordinarily should have been termed a waste material to be discarded, but was used with sodium hydroxide acting as a thickener to produce grease i.e. converting waste to wealth. Working within a temperature range from 30℃ to 60℃ for the different formula of grease produced, the viscosity, unworked penetration and dropping point were analysed. The viscosity decreased as temperature increased whereas the penetration time and dropping point showed an increase as temperature increased with increase of temperature up to 40℃. The consistency number for the grease was within and comparable with the consistency number of commercially available grease grades in the market. Hence, the formulated grease being used under the operating condition of 30℃ to 40℃ may serve as a substitute for the commercially available one in the market especially in application in bearing.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Rahul Tiwari, Manoj Khatana. Lubrication oil replacement technology. Int. J. On Recent Trends in Engineering and Technology. 2012;7(3):8–11.

2. Cutler ET. Conserve lube oil: Re-refine. Hydrocarbon Processing. 2009;265.
3. Concawe. The collection, disposal and regeneration of waste oil and related materials. Concawe Report. No. 85/53; 1985.
4. Dr.-Ing. Heino Vest. Reuse and refining of waste engine oil (1997, revised in 2000), Technical Information W17e. Available:www.gtz.de/gate/gateid.afp (Accessed 15 March 2015)
5. Harry MF. Standard handbook of hazardous waste and disposal. McGraw-hill Book Company, New York. 2005;782-793.
6. Ogbeide SO. An investigation to the recycling of spent engine oil. Journal of Engineering Science and Technology Review. 2010;3(1):32-35.
7. Ademola B, Luxembourg M. A new approach to caustic treatment of waste lubricants, waste treatment and utilization. Journals of Engineering Technology. 2001;3(2):43-47.
8. Udonne JD. A comparative study of recycling of used lubrication oils using distillation, acid and activated charcoal with clay methods. Journal of Petroleum and Gas Engineering. 2011;2(2):12-19.
9. Cooke VB. The role of additive in the automobile industry. ASLE; 1982.
10. Coyler CC. Gasoline engine oils: Performance, evaluation and classification. 10th World petroleum Congress, Moscow. 2000;112.
11. Cao Y, Yu L, Weimin LW. Study of the tribological behavior of sulfurized fatty acids as additives in rapeseed oil. Wear. 2000;244:126–131.
12. Whisman ML, Reynolds JW, Goetzinger JE, Cotton FO. Rerefining makes quality oils. Hydrocarbon Process. 1978;141-145.
13. Bennet AY. An engine test for predicting the performance of engine lubricants; 1960.
14. Georgel WC, La TGG. Extended engine oil life through new technology. Seminar paper at the National Petroleum Refiners Association 1977 Annual meeting, Mar 27 – 29, San Francisco, Carlifornia.
15. Pogosian A, Martirosyan T. Impact of surfactant structure on the tribological properties of bentonite-based greases. J. Tribol. 2007;129(4):920-924.
16. Hayder A Abdulbari, Rosli MY, Abdurrahman HN, Nizam MK. Lubricating grease from spent bleaching earth and waste cooking oil: Tribology properties. International Journal of the Physical Sciences. 2011;6(20):4695-4699.
17. Asseff PA. Lubricating oil additive, description and utilization. Lubricol Corp, Wicklif, Ohio, 1961;140-142.
18. Mortier RM, Orszulik ST. Chemistry and technology of lubricant VCH publishers, Inc. New York. 1994;108-112.
19. John Sander, Le White Paper; Putting the Simple Back into Viscosity, 2011 Lubrication Engineers Inc. 2011;1–11. Available:http://www.lelubricants.com/lit/news/White%20Papers/simple_viscosity.pdf (Accessed 25 May 2015)
20. Penrite Lubricants, Guide to Oils and Greases. Aug. 2008;40. Available:http://www.penriteoil.com.au/tech_pdfs/GUIDE%20TO%20OILS%20AND%20GREASES.pdf (Accessed 20 July 2015)

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