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Reclamation of Spent Automobile Engine Lubricating Oil

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Abstract

In this study, some of the property reclamation methods for spent lubricating oil (SLO) were demonstrated. Firstly, 3.5 L of SLO was subjected to physical methods such as natural settling, sedimentation, magnetisation and filtration to remove all forms of particles irrespective of size. The remaining samples were either subjected to acid treatment using concentrated sulphuric acid or solvent treatment using methanol, butanol and toluene including their blends to study their performance in the extraction process to recover the lubricating oil. The key parameter considered is the volume ratio of solvent/acid to used lubricating oil. In all, 5, 10, 15 and 20 ml respectively were used for each of the treatments. Activated carbon was equally introduced as adsorbent. A ratio of 4:1 (B20 formulation) for the treated spent oil and additives was used in this study for the final reclamation of the spent oil. The performance of each of the treatments process was investigated by subjecting all samples to laboratory analysis using American Standards for Testing and Methods (ASTM) to evaluate certain lubricating/tribological properties such as density, viscosity, pour point, cloud point etc. Both virgin oil and used oil were also simultaneously subjected to analysis with other recovered oil samples. The results suggest that the oil recovered by solvent treatments, particularly methanol exhibited better lubricating properties and can be rendered as good as virgin lubricants with the addition of certain additives. However, acid treatment demonstrated improved colour and appearance recovery compared to solvents.

Keywords: Tribological properties, viscosity, pour point, cloud point

Introduction

Used lubricant is petroleum-based lubricating oil which, through use, storage or handling, has become unsuitable for the purpose for which it was originally designed, in particular used oil from combustion engines, automobile engines, and transmission systems, as well as mineral oils for machinery, turbines and hydraulic systems. Recycling of used oil is the need of the hour, because of economic, environmental, public health and legal reasons (Mithilesh, 2005). There is serious wastage in the lube oil economy. EPA (Environmental Protection Agency) statistics show that each year in the United state, approximately

200 million gallons of used oil is dumped into the environment (USEPA, 1994). The demand of finished lube oil in different sectors in Bangladesh is about 100,000 tonnes per year; of which 70% is used for gasoline engine oil, diesel engine oil, automotive gear oil, motor cycle engine oil and rest 30% is used as industrial oil and marine engine oil (Ahmed, 2007), similarly, the total number of registered auto vehicles is around 1.2 million in same location (Siddiquee and Samdani, 2008). These vehicles change their engine oil after two or

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or 3000 - 5000 km mileage; this of course results in corresponding generation of waste oil. In Canada approximately about 1 billion litres of lubricating oils are sold annually but only about 200 million litres are recovered, in other words more than half is wasted and disposed to the environment (Kayode, 1995). As at 1996, Nigeria accounted for more than 364 million litres of lubricating oil consumption (Victor and Sadiq, 2002). Table 1.0 below also describes base oil situation in Nigeria. There are basically three options to deal with the waste oil in the world; re-processing into fuel oil and Lube oil, extracting of heat value of waste oil through combustion process and used as weed killer or wood preservation.

The first and second options are intelligent options for any country, which is in line with our attempt in this study. A litre of used oil reprocessed as fuel contains about 8,000 KJ of energy, which is enough energy to light a 100W bulb for 1 day or to operate a 1000W electric heater for 2 hours. Also while 67 litres of crude oil are needed to obtain a litre of motor oil, only 1.6 litres of used oil are required to produce the same amount of motor oil (EPA Report 530, 1996). As acclaimed in the study of Mithilesh (2005), lubricating oil does not wear out during use. It is only the additive part, which gets depleted. The oil molecules are not degraded, but because of presence of contaminants numerous to mention, oil needs replacement. Nabil *et al.* (2010) treated waste lubricating oil treatment by adsorption process using different adsorbents. Araujo and Telles, (1995) showed that the final treatment of the used oil recycling process is the decolorization and neutralization. Vaughn, (1975) reported the recycling of used lubricating oil using the acid/clay method. Extraction of used lubricating oils with supercritical carbon dioxide as solvent has also been proposed as an environmentally friendly process (Krukoni, 1994). Physical treatment by distillation and thin film evaporation method have also been reported by Brinkman *et al.* (1981) as successful method of lubricant re-refining. However, in this study, we introduce certain physical methods, acids and solvents to chemically treat the used oil as

potential method for direct re-use, re-processing, reclamation and regeneration to greatly avoid gross waste of the non-renewable mineral resources.

Materials and methods

One of the brands of Lubcon products coded LUBCON SUPER XV; high performance multigrade motor oil (specification SAE: 20W/50 and API: SF/CD) and its spent derivatives were used in this study. Used lubricating oil samples were obtained after an engine run of about 5000 km from a primera car (petrol engine, SLX Model 2001). All other reagents used in this research were of analytical grade and used without further purification. A volume of about 3.5 L of used oil was obtained and placed in a 4 L plastic container for a week for natural sedimentation to take place as part of the physical treatment. Impurities such as sand, metals etc left as sediments were discarded while retaining the top layer. The used lubricating oil was further filtered to remove other tiny impurities that are contained in the lube base oil. This was done using a funnel with a filter paper placed in it, then a vacuum pump was connected to the buchner funnel. A magnet was placed in the filtered oil for about 24 hours to further remove tiny metallic/ferrous metals that may be present. The decanted oil with the introduction of little quantity of activated carbon for colour improvement was poured into 5 different 500 mL conical flasks and placed in an orbital shaker at 250 rpm for 90 minutes to further allow other tiny impurities to settle under gravity and re-decanted. The final decanted oil was treated with 5, 10, 15 and 20 mL of concentrated H₂SO₄ and methanol respectively and heated in a water bath at 600 C for 30 minutes. A ratio of 4:1 (B20 formulation) for the treated used oil and additives was used in this study for the final reclamation of the used oil.

Results and Discussion

The sample B was very dark in appearance, colour and clarity, which is an indication of contamination with series of particles. A was very clear while others show very slight improvement in appearance. Analysis carried out shows that all

Table 1: Major Actors in the Virgin Oil Production and Supply in Nigeria

Major marketers	Level of importation of base oils Million Litres/Annum	Grades of lubricants produced Million Litres/Annum
Mobil Oil Nigeria Plc.	12.4	Monograde, Multigrade, Marine lubricant, Industrial lubricants
African Petroleum Plc.	8.0	Petrol and diesel engine oils, hydraulic oils
Texaco	9.0	Engine oils, industrial oil (turbines/compressors), gear oils
Conoil	15.0	Engine oils
Romi (Independent Marketer)	30.0	Engine oils
Ibeto (Independent Marketer)	60.0	Engine oils
Pract Oil (Independent Marketer)	40.0	Engine oils
Dozy (Independent Marketer)	50.0	Engine oils
A-Z (Independent Marketer)	40.0	Engine oils
Total	264.4	

Source: Bamiro. And Osibanjo (2004)

the samples are devoid of water, which shows proper handling and storage. The densities of G, I and F (Table 2) were very close in that order to A showing a slight improvement in the density of the used oil. In other to optimize the engine performance and exhaust emissions, lubricant density must be controlled within a fairly narrow range. All except sample A show considerable improvement in viscosity which is a very important parameter in classifying lubricants. High viscosity reduces lubricating oil flow rate, resulting in insufficient flow. Wear may increase with low viscosity, as lubricity tends to decrease with viscosity. Sample I shows a unique resemblance to A in terms of their degree of acidity and alkalinity closely followed by H. The temperature at which wax crystals begin to form on the surface of the oil is the cloud point. It is therefore important to note that all the samples under consideration have pour points that satisfy

their use as engine lubricating oils with sample G having the same pour point as the virgin sample. The pour point is minimum temperature of a liquid, particularly a lubricant after which on decreasing the temperature the samples cease to flow.

Conclusion and Recommendation

There is growing awareness about the polluting effects of used lubricating oil. They are either indiscriminately discharged into the immediate environment or burnt thereby further polluting the already polluted environment. The recycling of used lubricating oil will reduce environmental concern, which it has so far posed. It will also reduce the demand for lubricant rich crude whose reserve is becoming finite. Lubricating oil does not wear out during use. It is only the additive part, which gets depleted. The oil molecules are not degraded, but because of presence of contaminants, oil needs replacement time to time.

Table 2: Results of laboratory analysis of the used oil, treated used oil and virgin oil.

Properties/Samples	A	B	C	D	E	F	G	H	I	J
Water contents	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Density, g/cm ³ (ASTM D289)	1.099	1.119	1.165	1.13	1.107	1.027	1.091	1.122	1.051	1.111
Viscosity mpas, 25°C (ASTM D2393)	163.6	100.8	108.1	107	107.2	107.4	107.2	97.78	107.4	107.4
p ^H	6.54	5.48	3.93	3.65	3.88	3.46	5.99	6.82	6.54	7.36
Colour (ASTMD1500)	>5	>5	>5	>5	>5	>5	>5	>5	>5	>5
Cloud Point, °C (ASTM D2500)	22	20	20	20	21	20	22	21	21	20
Pour Point °C (ASTM D97)	16	14	13	13	13	12	12	12	14	11

Legends:

A: Virgin oil (LUBCON SUPER XV with specification SAE: 20W/50 and API: SF/CD)

B: Used oil (U.E)

C: 20 ml U.O + 20 ml H₂SO₄

D. 20 ml U.O + 15 ml H₂SO₄

E. 20 ml U.O + 10 ml H₂SO₄

F. 20 ml U.O + 5 ml H₂SO₄

G. 20 ml U.O + 20 ml methanol

H. 20 ml U.O + 15 ml methanol

I. 20 ml U.O + 10 ml methanol

J. 20 ml U.O + 5 ml methanol

The reclamation methods used include physical, acid and solvent treatment. Just slight improvements were noticed in most of the samples when compared with the virgin oil with the solvent treatment exhibiting better properties. The fact that the solvents are recoverable, therefore, renders the solvent processes cost effective. Samples subjected to acid treatment show better colour improvement compared with those treated with solvents. Recommendation from this study is the use of green solvents for the recovery process. Since the solvent method enhanced property recovery and acid treatment shows better colour improvement, the blend of the two (solvent; organophilic and acid; hydrophobic) at different molar ratios under varying thermal conditions are further recommended for study.

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