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RECYCLING OF USED LUBRICATING OIL USING DIFFERENT AGENTS

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Abstract*-This paper addresses recycling of used engine oil that was treated by the use of sulfuric acid and phosphoric acid. Recycling of used motor oil is a well – recognized alternative of world – wide power resources conservation, with a growing significance in the context of the limited resources of fossil fuels. It also represents a viable way of protecting the natural environment. The used motor oils are polluted by pollutants and impurities resulted from undesirable oxidation processes: sediment, water, metallic particles and degraded additives. The recycling of used motor oil implies the removal of contaminants. There are several recycling methods; this research followed the basic steps: acid treatment, sedimentation/decantation, bleaching, neutralization, sedimentation/decantation and filtration. The used oil samples subjected to the experiment was drawn from the automotive service stations. Sulfuric acid and phosphoric acid were used in acid treatment. The bleaching was achieved by industrial bleaching earth. Sodium hydroxide was employed in neutralization. At the end of sedimentation/decantation and filtration, recycled oil was obtained. The values of characteristics parameters of the recycled oil were presented compared to those of used and fresh oil. The results showed variations of the measured properties which depend both on the type of acid used and source of waste oil.*

Keywords: Used engine oil, sulfuric acid, phosphoric acid, recycling, fresh oil

1. INTRODUCTION

Waste lubricating oil is a high pollutant material. So, it requires responsible management. Waste engine oil may pollute the environment if it is dumped into the ground or into water streams including sewers. This may cause contamination of groundwater and soil. Engine oil costs will be reduced if such contaminated materials are recycled. Also, it will bear a great positive impact on the environment.

Lubricating oil protects rubbing surfaces, lowers friction between moving and connected parts, eliminates rise of temperature on the moving surfaces and keeps the engine clean. The major service characteristics of lubricating oil are their viscosity, viscosity temperature properties, fluidity at low temperatures, chemical stability and protective properties. Engine oil has viscosities ranging from 10 to 1000 centistokes at 100℉.

The engine oil is derived from petroleum base feedstock which primarily consists of complex mixtures of hydrocarbon molecules. They normally range from low to high viscosity oil. Studies have shown that lube oil consist of aromatics in the range of 4 to 12% free sulfur and other impurities depending on the source of hydrocarbon crude oil process and the production method. The color and odor of engine oil are mostly caused by the nitrogen, sulfur and oxygen compound concentrated in the crude oil and residue fraction. Analysis of the aromatic of the lube base oil shows that aromatics are in homogeneity with the other compounds. Most of the aromatics present in engine oil are poly nuclear in nature. The used engine oils like automobile engine oils are derived from petroleum and originally produced through acid and bleaching treatment, vacuum distillation, solvent extraction, multiple refining steps and hydro finishing.

During normal use, many contaminants such as dirt, metal scrapings, water, and chemicals can get mixed in the lubricating oil, so the oil will be ineffective for further use. Oil does not wear out it only gets dirty after use. Because of uncontrolled dumping and land filling of the used oil in the environment, the environment is largely affected.

Lubricating oil is produced at a huge amount all over the world. The used oils are frequently dumped into gutters, water drains, open plots etc. in Bangladesh. This contaminates ground water, streams, lakes and oceans. Investigations show that one gallon of used engine oil can pollute million gallons of fresh drinking oil. Disposing of used oil on ground can reduce fertility of soil and makes the plants grown on the soil improper for food and forage. Adsorption is one of the significant method of recovery [1-

2]. Analyses are being carried out for waste water treatment of petroleum industries [3-5]. There are many investigations which are directed towards enhanced oil recovery [7-9].

Waste lubricating oil means the engine oil, transmission oil, hydraulic and cutting oils after use. It refers to degradation of fresh lubricating oil components that become polluted by metals, ash, carbon residue, water, varnish, gums and other polluting materials, also asphaltic compounds derived from the bearing surface of the engines. Changing and removal of these oils from the automobile is a must after driving a few thousand kilometers because of stress from serious deterioration in service. The great quantity of waste engine oils has a major impact on both economical and environmental aspects. They cost millions of dollars to produce and refer to high pollutant material when dumped.

A recommended solution for this issue is the regeneration of lubricating oil from waste oil. Regeneration of waste lubricating oil simply refers to the removal of contaminants by sulphonating agents such as sulfuric acid, oleum or sulfur trioxide. About 80% aromatics and other pollutants are eliminated in the first circle of operation. When the engine operates, there is decline in significant properties of lubricating oil like viscosity, specific gravity and flash point because of rise in temperature of the oil. Also, dirt particles and metal parts get mixed in the oil.

The purpose of this research is focused mainly on treating used motor oil so the product can be used as a fuel, thus reducing environmental pollution. For this purpose, sulfuric acid and phosphoric acid will be used in the treatment of waste lubricating oil followed by clay treatment.

The objectives of this research are recycling the used engine oil by using sulfuric acid and phosphoric acid and achieving the properties of the recycled oil close to that of fresh engine oil.

2. METHODOLOGY

2.1 Materials Used

The chemicals used in recycling the used engine oil are sulphuric acid, phosphoric acid, activated bleaching earth and sodium hydroxide. The apparatus and equipment used are precision electronic balance, oven, magnetic stirrer, beaker, funnel, thermometer, viscometer, flash point tester, digital bomb calorimeter.

2.2 Different Steps of Recycling Process

2.2.1 Treatment with Sulfuric and Phosphoric Acid

Firstly, 300 ml of used lubricating oil will be measured by measuring cylinder and transferred into a 500 ml beaker. Again, 30ml of acids (sulfuric acid, phosphoric acid) will be measured in a separate 50 ml beaker. Then the beaker with used engine oil will be kept in an oven to supply heat. The temperature of the base oil i.e. used engine oil will be maintained at 40 – 45℃. At this temperature, the acid (sulfuric acid and phosphoric acid) will be introduced into the used oil simultaneously with stirring of the mixture for 10 minutes [21-22].

2.2.2 Sedimentation /Decantation

At the end of acid treatment step, the acidic oil will be allowed to settle for 24 hours to form sediment at the bottom of the beaker. After this period, I will properly sediment and decant the acidic oil into another 500 ml beaker using piece of cloth while the residue (acidic sludge) at the bottom of the beaker will be discarded [21-22].

2.2.3 Bleaching

Bleaching will be carried out on the acidic oil in the beaker. The acidic oil will be kept in an oven and its temperature will be increased to 110℃. Then 6 wt% of activated bleaching earth will be introduced into the oil and mixture will be continuously stirred for 15 minutes. At the end of bleaching stage, I will neutralize the bleached oil [21-22].

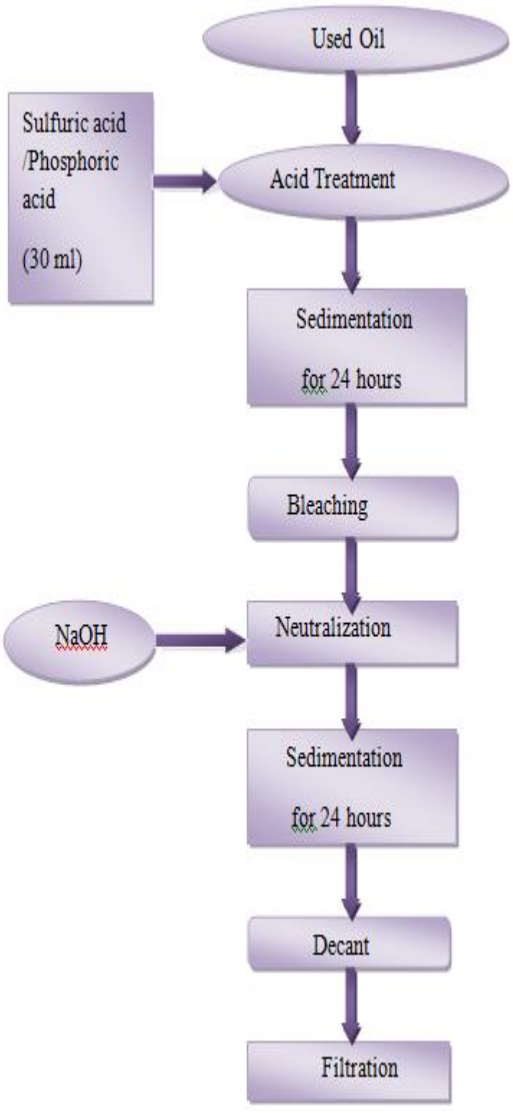

Fig.1: Flow diagram of regeneration of used lubricating oil

2.2.4 Neutralization

The bleached oil will be subjected to neutralization process to adjust the PH of the acidic oil. In this stage, 4 wt% of the oil of sodium hydroxide will be introduced into the bleached oil by taking into consideration the PH of the bleached oil at a given point of time. The bleached oil will be neutralized by a continuous manual stirring for 10 minutes. At the end of bleaching and neutralization steps, the oil will be allowed to sediment in the beaker for 24 hours and will be decanted into the beaker. The residue at the bottom of the beaker will be discarded [21-22].

2.2.5 Sedimentation /Decantation

At this step, I will allow to settle the oil in the beaker for 24 hours and will decant into another beaker and the residue at the bottom will be discarded [21-22].

2.2.6 Filtration

The sediment oil will be finally filtered using a filter cloth and the filtrate will be collected in a filtration flask and will be observed to be clear and the residue will be discarded [21-22].

3. RESULTS

In table 1 comparison between the fresh engine oil, used engine oil and treated oil with sulphuric acid and phosphoric acid is stated briefly.

Table 1: Test analysis of the used engine oil, fresh engine oil and recycled oil

Parameters	Fresh Engine Oil (SAE 20W-50)	Used Engine Oil	Treated oil with sulfuric acid	Treated oil with phosphoric acid	Treated with acetic acid (reference value)	Treated with formic acid (reference value)
Density (g/ml)	0.88	0.96	0.92	0.93	0.917	0.914
Specific gravity	0.88	0.96	0.92	0.93	0.917	0.914
Dynamic viscosity at 32°C(cp)	25	16.5	23.9	19.4	21.5	22.9
Kinematic viscosity at 32°C(cp)	28.4	17.19	25.97	20.86	23.4	25.05
Color	Dark Red	Very Dark	Dark Brown	Dark Brown	Dark Brown	Dark Brown
Pour point	-8.8° C	-18°C	-10.3° C	-10.8° C		
Flash point	232° C	178° C	210° C	200° C		
Calorific value (kcal/kg)	9.95	9.47	9.58	9.52		

The graphs comparing the values of the fresh, used and recycled oils for different properties are shown below. Because of building up of temperature and mixing of contaminants with the fresh oil, it loses its functional properties.

In Figure 2 ,the density of the used oil was observed higher compared to fresh oil because the density of the used oil increase with oil combustion in the engine with the fuel, which results in impurities and thus the density is increased. When the used oil was treated with sulfuric acid and phosphoric acid, the density decreased.

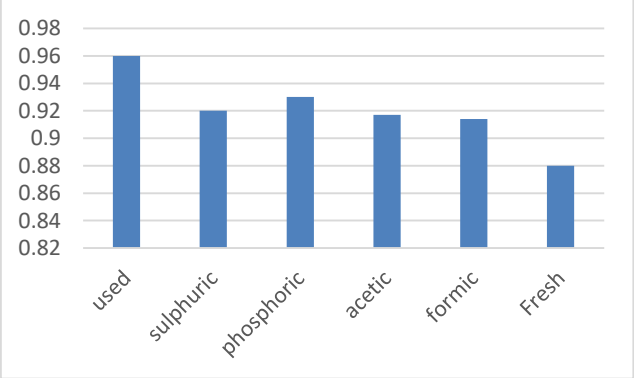

Fig.2: Density of fresh oil, used oil and recycled oils using sulphuric and phosphoric acids

Figure 3 shows the comparison of the values that was obtained from recycling the used oil using sulphuric and phosphoric acid and the values obtained by using acetic and formic acid. The values of specific gravity obtained by treating the used oil with acetic and formic acid were 0.917 and 0.914 respectively. By treating with sulphuric and phosphoric acid it was 0.92 and 0.93 respectively. So it is found that the specific gravity of the recycled oil is comparatively much closer to that of fresh oil when the used oil is treated with formic acid

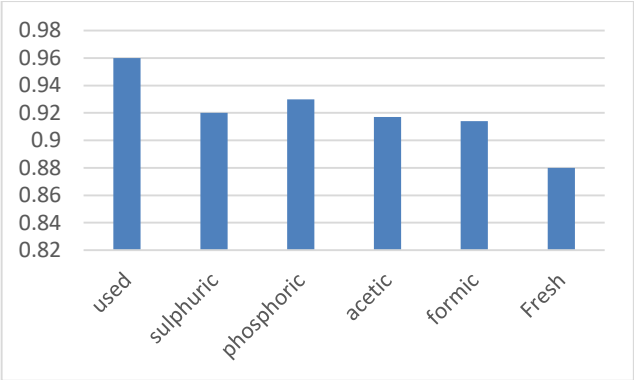

Fig.3: Specific gravity of fresh oil, used oil and treated oils with formic, acetic, sulphuric and phosphoric acid

In figure 4 the dynamic viscosity of the used oil was observed lower compared to the fresh oil. The viscosity of the used oil decrease with oil combustion in the engine with the fuel, which results in impurities, the results showed the treated oil with sulphuric and formic acid close to that of fresh oil. The experiment was conducted at oil: acid ratio which was 10: 1.

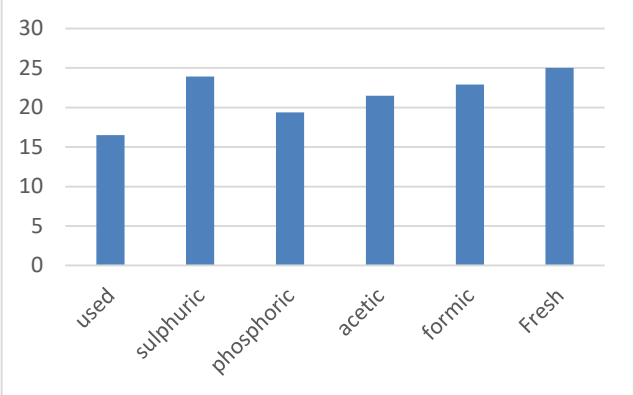

Fig.4: Dynamic viscosity of fresh oil, used oil and treated oils with sulphuric acid, phosphoric acid, acetic acid and formic acid

In figure 5 the values of kinematic viscosity of fresh oil, used oil and oils treated using sulphuric acid, phosphoric acid, acetic acid and formic acid is compared. The values using acetic and formic acid were obtained 23.4 cp and 25.05 cp respectively. The values were 25.97 cp using sulphuric acid and 20.86 cp using phosphoric acid. Comparing all those values it is observed that the recycled oil using sulphuric acid has the value of kinematic viscosity which is the closest to the fresh engine oil.

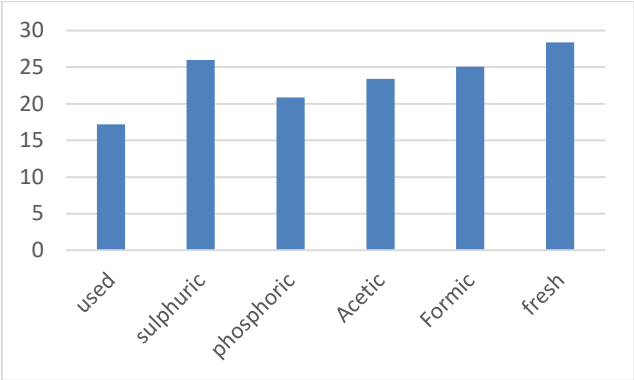

Fig.5: Kinematic viscosity of fresh oil, used oil and treated oils with sulphuric acid, phosphoric acid, acetic acid and formic acid

In figure 6 the pour point of the used oil was observed to be lower than that of fresh oil. After treating the used oil with sulphuric and phosphoric acids the pour point became closer to that of fresh oil. The pour points of used oil and fresh oil were -18°C and -8.8°C respectively. The pour points of treated oils using sulphuric and phosphoric acids were -10.3°C and -10.8°C respectively. It is observed that the acid treatment process is effective as the values of recycled oils were much closer to that of fresh oil.

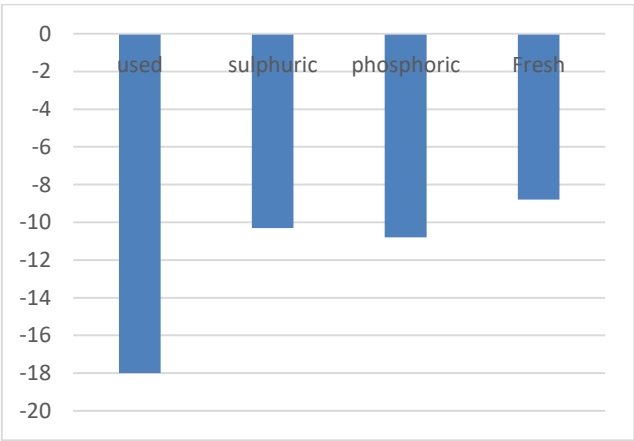

Fig.6: Pour point of fresh oil, used oil and treated oils with sulphuric acid and phosphoric acid

In figure 7 the flash point of the fresh oil was observed higher compared to the used oil. The flash points of used oil and fresh oil were 172°C and 232°C respectively. After recycling the used oil using sulphuric and phosphoric acids, the flash points became 210°C and 200°C. So the flash points of recycled oils were closed to that of fresh oil although more precise result was expected

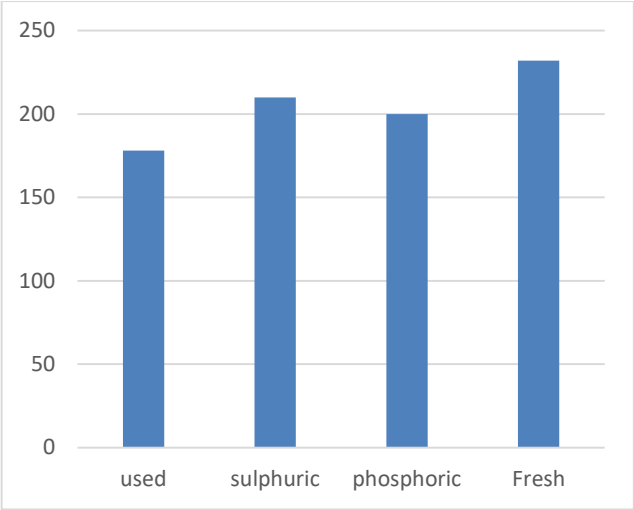

Fig.7: Flash point of fresh oil, used oil and treated oils with sulphuric acid and phosphoric acid

In figure 8 it is observed that the calorific value of fresh oil is much higher than that of used oil. After recycling the used oil with sulphuric and phosphoric acids the calorific value improved though much better result was expected.

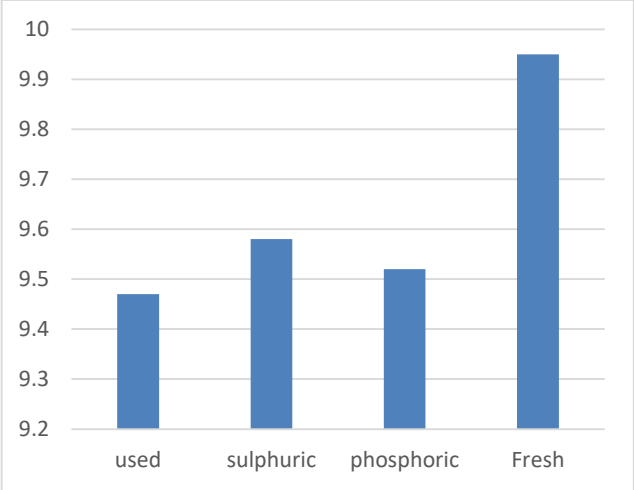

Fig.8: Calorific value of fresh oil, used oil and treated oils with sulphuric acid and phosphoric acid

4. CONCLUSION

The recycling method using different acids is proved to be efficient considering the results obtained. From the results it is found that the process effectively removed pollutants from used lubricating oil. This method is very cost effective compared to the other methods. It will also decrease the demand for lubricant rich crude which is a finite source. The recycling of used lubricating oil will reduce environmental concern. The recycled oil that was obtained by experiment in this work might not be suitable for using in automobiles. But after some modifications the recycled oil produced by this method will be appropriate for using in automobiles. Moreover, this process reduces water pollution by preventing us from dumping the used oils in water sources. So recycling of used oils is an effective method to be applied because of its advantages like environment conservation and cost effectiveness.

5.REFERENCES

[1] Reza Behnood, Bagher Anvaripour, Nematollah Jaafarzade, Haghighi Fard and Masoumeh Farasati, 2013, "Applications of Natural Sorbents in Crude Oil Adsorption", Iranian Journal of Oil & Gas Science & Technology, 2(4), PP. 01-11.

[2] Nabil M. Abdel – Jabbar, Essam A.H. Al Zubaidy, and Mehrab Mehrvar, 2010, "Waste Lubricating Oil Treatment by Adsorption Process Using Different Adsorbents", International Journal of Chemical and Biological Engineering, 3(2), PP. 70 – 73.

[3] H.A.Gasim, S.R.M Kutty, M.Hasnain Isa, and L.T. Alemu (2013), "Optimization of Anaerobic treatment of Petroleum Refinery Wastewater Using Artificial Neural Networks", Research Journal on Applied Sciences, Engineering and Technology, 6(11), PP. 2077 – 2082.

[4] Basheer Hasan Diya, Uddeen, Wan Mohd Ashri, Wan daud, A.R. Abdul Aziz (2011), "Treatment Technologies for petroleum refinery effluents: A review", Process Safety and Environmental protection, 89, PP. 95 – 105.

[5] Sergio A. Martinez – Delgadillo, Miguel A. Morales – Mora and Icela D. Barcelo – Quintal (2010), "Electrocoagulation Treatment to Remove Pollutants from Petroleum Refinery Wastewater", Sustain. Environ. Res., 20(4), PP. 227- 231.

[6] Sunil Jayant Kulkarni, "An Insight into Oil and Grease Removal from Wastewater from Petroleum and Refinery Industries", International Journal on Petroleum and Petrochemical Engineering (IJPPE), 2(1), PP. 12 – 15.

[7] Karovic Maricic Vesna, Lekovic Branko, Danilovic Dusan, 2014, "Factors Influencing Successful Implementation of Enhanced Oil Recovery Projects", Underground Mining Engineering, 25, PP. 41 – 50.

[8] Abubaker H. Alagorni, Zulkefli Bin Yaacob, and Abdurrahman H. nour, 2015, "An Overview of Oil Production Stages: Enhanced Oil Recovery Techniques and Nitrogen Injection", International Journal of Environmental Science and Development, 6(9), PP. 693 – 702.

[9] Sunil Jayant Kulkarni, 2017, "An Insight into Research and Studies on Enhanced Oil Recovery (EOR) in Petroleum Industries", International Journal of Petroleum and Petrochemical Engineering (IJPPE), 3(2), PP. 1 – 4.

[10] Shri Kannan C, Mohan Kumar KS, Sakeer Hussain M, Deepa Priya N and Saravanan K, 20144, "Studies on Reuse of Re – Refined Used Automotive Lubricating Oil", Research Journal of Engineering Sciences, 3(6), PP. 8 – 14.

[11] Mohd. Nematullah Nasim, M. Sohail Parvez, Ravindra Babu Yarasu, Namrata V Lotia, 2014, "Recycling Waste Automotive Engine Oil as Alternative Fuel for Diesel Engine: A Review", IOSR Journal of Mechanical and Civil Engineering, 1, PP. 46 – 50.

[12] Motshumi J. Diphare, Edison Muzenda, Tsietsi J. Pilusa and Mansoor Mollagee, 2013, "A Comparison of waste Lubricating Oil Treatment Techniques", 2nd International Conference on Environment, Agriculture and Food Sciences (ICEAFS'2013) August 25 – 26, 2013 Kuala Lampur (Malaysia), 1, PP. 106 – 109.

[13] M. Kannan and Dr. C.G. Saravanan, 2014, "Characterization of alumina catalyst in the catalytic fuel reformer", American International Journal of Research in Science, Technology, Engineering & Mathematics, 7(2), PP. 127 – 131.

[14] F. Danane, A. Ahmia2, A. Bakiri and N. Lalaoui, 2014, "Experimental regeneration process of used motor oils, Revue des Energies Renouvelables", 17(2), PP. 345 – 351.

[15] Udonne J.D., 2011, "A comparative study of recycling of used lubrication oils using distillation, acid and activated charcoal with clay methods", Journal of Petroleum and Gas Engineering, 2(2), PP. 12 – 19.

[16] Jhanani. S, Kurian Joseph, 2011, "Used oil generation and management in the automotive industries", International Journal of Applied Engineering Research, Dindigul, 2(1), PP.135 – 146.

[17] Hayalu Andargachew Mekonnen, Ing. Abubeker Yimam, 2014, "Recycling of Used Lubricating Oil Using Acid – Clay Treatment Process", Addis Ababa University Addis Ababa Institute of Technology (Aait) School of Chemical and Bio – Engineering (MSc. Program in Environmental Engineering), 1, PP. 1 – 80.

[18] Christopher D. DeDene and Zhanping You, 2014, "The Performance of Aged Asphalt Materials Rejuvenated with Waste Engine Oil", Int. J. Pavement Res. Technol.,7(2), PP. 145 – 152.

[19] Zitte LF, Awi – Waadu GDB and Okorodike CG, 2016, "Used – Oil Generation and its Disposal along East – West Road, Port Harcourt Nigeria", Int J Waste Resour, 6(1), PP. 1 – 5.

[20] Eman A. Emam, Abeer M. Shoaib, 2012, "Re – refining of Used Lube Oil, II- by Solvent/Clay and Acid/Clay – Percolation Processes", ARPN Journal of Science and Technology, 2(11), PP. 10341041.

[21] Isah, A.G., Abdulkadir, M., Onifade, K. R. Musa, U., Garba, M. U. Bawa, A. A and Sani, Y., 2013, "Regeneration of Used Engine Oil", Proceedings of the World Congress on Engineering 2013 Vol I, WCE 2013, July 3 – 5, 2013, London, U.K., PP. 1 – 4.

[22] Salah Eldeen F. Hegazi, Yasir A. Mohamd, Mohammed Ibrahim Hassan, 2017, "Recycling of Waste Engine Oils Using Different Acids as Washing Agents", Int J Oil, Gas and Coal Engineering, 5(5), 2017, PP. 69 – 74.