Available online at http://ijcpe.uobaghdad.edu.iq and www.iasj.net
Iraqi Journal of Chemical and Petroleum Engineering
Vol.23 No.1 (March 2022) 43 – 50
EISSN: 2618-0707, PISSN: 1997-4884

Treatment of Used lubricant Oil by Solvent Extraction

Tariq M. Naife[a], Sarmad A. Rashid[a] and Marwa F. Abdul Jabbar[b]

[a] *University of Baghdad, Chemical Engineering Department, Baghdad, Iraq*
[b] *AL-Nahrain University, Chemical Engineering Department, Baghdad, Iraq*

Abstract

This study investigates the treatment of used lubricating oils from AL-Mussaib Gas Power Station Company-Iraq, which was treated with different extractive solvents (heptane and 2-propanol). The performance activity of these solvents in the extraction process was examined and evaluated experimentally. Operating parameters were solvent to oil ratios of (1:2, 1:4, 1:6, and 1:8), mixing time (20, 35, 50, and 65 min), temperatures (30, 40, 50, and 60 ºC), and mixing speed (500 rpm). These parameters were studied and analyzed. The quality is determined by the measuring and assessment of important characteristics specially viscosity, viscosity index, specific gravity, pour point, flash point, and ash content. The results confirm that the solvent 2-Propanol gave great proficiency with the most elevated percent of sludge removal compared with heptane. The greatest percentage of waste removal is enhanced when the solvent/oil ratio increases with optimal economic aspects. The significant characteristics of the reused lubricating oil were estimated. The outcome of the results indicates that the adjustment of the characteristics of reused oil has great effectiveness and the best working conditions for 2-Propanol (35 min, 1:6 S/O ratio, 40 ºC), and heptane (50 min, 1:6 S/O ratio, 50 ºC).

Keywords: used lubricating oil, characteristics of lubricating oil, and solvent extraction.

Received on 07/03/2022, Accepted on 28/03/2022, published on 30/03/2022

https://doi.org/10.31699/IJCPE.2022.1.6

1- Introduction

The principal functions of lubricants are to work on the perfection of the smoothness of contact and movement parts from one surface to another and thus reduce the friction between these surfaces, as well as decrease the contact friction of the various parts of machine or engine, retain heat, deny corrosion, and deter contamination. As a result, a thin lubricant film between the contact surfaces prevents wear and reduces power loss [1, 2]. In working, the lubricant oil loses its efficiency gradually and degrades with time. The percent of this degradation depends on several factors, such as the environment, the quality of the lubricant, and operating conditions. However, the engine oil has reached a point that will no longer time to be able for performing its functions with good performance [3,4], so, at this point, this oil must be changed and replaced from the engine because of losses in efficiency and stress from real deterioration in service [5].

One of the public's most used methods of disposal is used in many sectors such as vehicles, industries, and the production of electricity for different functions such as minimizing friction between moving parts that contact each other, heat dispersion, the transmission of power [6,7].

Used lubricating oils, which are hard to handle anthropogenic poisons or pollutants because of their poisonousness and have become unwanted for use.

The reusing of waste oil might be a fitting and modest option in contrast to incineration [8]. For economic reasons, the convenient substitutional to incinerate used oil by recycling. The necessity for the recycling of utilized lubricant oil for conceivable reuse has appeared because of attention to the environment, industrial lubricant stability, as well as a growing reliance on this product for industrial purposes [9,10]. The amount measured of used lubricating oil in Iraq that is used annually is exceptionally enormous. This enormous amount of utilized engine and power generation oil fundamentally affects both economic and environmental aspects, in many cases the cost a lot of money/birr to make and are a rising toxin and pollution substance when rejected. Whenever released these pollutants are into the land, ecosystem, water, or even consumed as poor quality oil [11].

There are several reuse methods have been proposed for the treatment of used lubricant oils. A suggested solution to this study is the recapture functionating of the lubricant base oil depending on the used oil [12]. Treating methods for using lubricating oil with solvents that are non-poisonous and cost-effective is the ideal solution [13]. Various methods have been created and developed that can be used for the processing of used mobile and total lubricant oil samples to enhance their specifications and quality for reuse, like that waste oils, have also been re-refined to base oil utilizing a process known as hydrotreating or hydro finishing [14].

Corresponding Authors: Name: Tariq M. Naife, Email: tariq.mohammed@coeng.uobaghdad.edu.iq, Name: Sarmad A. Rashid, Email: Sermed.rashid@coeng.uobaghdad.edu.iq , Name: Marwa F. Abdul Jabbar, Email: marwa84_2007@yahoo.com

Reusing used lubricant oil can either reestablish the base use of the lubricant oil or eliminate the pollutants to the extent that it can be turned into a convenient medium for subsequent use. Solvent extraction is one of the most compelling processes for the recycling of waste lubricant oil [15-20].

There are plans to recover the lubricating oil to conserve natural local resources. These are the most appealing recycling technologies in general. The solvents choices ought to have the greatest solubility for virgin oil and the least amount of additive carbonaceous.

The solvents then can be recovered by refining for recycling purposes [9].

Solvent refining by extraction is dependent on the properties of the original stock. Furthermore, Because of different service periods, the chemical composition of used lubricating oil fluctuates and is complicated to characterize, besides the solvent type and concentration employed [21].

This study's main commitment is to minimize the percentage of oil misfortunes by using suitable solvent extraction. Various variables, such as solvent/oil ratio, extraction conditions, and kinds of solvents, are also examined. Refine the used lubricating oil and recycle using a solvent extraction treatment procedure, as well as compare the solvent efficiency for reused or mixed into lubricating products, reducing the use of virgin oil. This study is exceptionally huge for our country since it settles and solves environmental problems due to using lubricating oil from gas power stations in all countries.

2- Experimental Work

2.1. Materials

a. Lubricating oils, both fresh and used

Fresh and utilized lubricating oil (Mobil jet oil) was obtained and collected from AL-Mussaib Gas Power Station Company (Ministry of Electricity-Iraq) and applied to an electrical power generator of 400 Kva type by Perkin Company For about 72 hours. The lubricating oils were emptied of gathered from the generator of electric power for treatment and examination, analyzing the properties of both fresh and used Table **1**.

Table 1. Specifications for both fresh and used lubricating oil

Characteristics	Fresh Generator oil	Used Generator oil
Specific gravity at 15°C/15°C	1.0035	1.1052
Viscosity at 40°C ,cst	27.6	48.7
Viscosity at 100°C ,cst	5.1	9.1
Viscosity Index	107.43	111
Flash point , °C	292	268
Pour point ,°C	-43	-54
Ash Content ,wt%	0.00	1.174
Water content, ppm	31	52
Carbon residue, wt%	1.56	0.02

b. Solvents

There are two types of solvents used in this study 2-Propanol (Sigma-Aldrich) and heptane (HOPKIN & WILLAMS Ind.), all with a purity of 99% were analytical grade.

2.2. Extraction Experiments

a. Pre-treatment

This step is very important and is required at the beginning of the process. The first treatment involves removing suspended solids from used lubricant oil, which are separated after mixing by a homogenizer and allowed to settle down. After that, the sample was collected and filtered under vacuum pressure (5 mm Hg) for the disposal of suspended solids.

b. Dehydration

The dehydration step is very necessary for removing a little bit of water which is restricted to working out under normal engine operating conditions, mainly because of air entry. For dehydration step, put a suitable amount of the used lubricating oil in the lower part of the flask, The used oil was permitted to settle down for 24 hours, As a result, simple decantation of the thick aqueous phase with its associated contaminants is possible. This step was carried out with an atmospheric distillation system to a temperature of 125 °C, this temperature was chosen to be confident that all water be evaporated for the reason that. This process continues till no distillate was received. The unit of distillation consists of a heating source with a 500 ml capacity, 220v 50/60Hz, 320w, and a 500 ml Pyrex flask joined to a condenser. The condenser has two holes for water flow that is supplied for cooling from a water tap, joined to the inclined neck, and the second neck is joined to the thermometer at a maximum range of 250 ^{o}C. Put the flask below the condenser as a reservoir, with a 250 ml flask as the volumetric flask [22].

c. Removal of light cuts

The conceivable elimination of light ends in feedstock energy is conceivable with the utilization of a basic batch vacuum distillation setup that worked at a temperature of 220 °C and a vacuum pressure of 5 mm Hg. The vacuum distillation step was done for about 60 min, this time is enough to remove light cuts.

d. Solvent Extraction

A laboratory batch extraction unit was used for the contacting step. Varying the solvent-to-oil ratios (1:2, 1:4, 1:6, and 1:8), temperatures (30, 40, 50, and 60 °C), mixing times (20, 35, 50, and 65 minutes), and mixing speeds (500 rpm) The mixture is left for 3 hours to separate as mentioned in literature [21,22].

After a steady-state is demonstrated by a steady level, the two phases are separated by utilizing a separating funnel. When the blended mixture separates into two layers (raffinate and separate), so, used an effective solvent. The virgin oil is extracted from the used oil using a solvent, while contaminants are separated, settled down, and withdrawn. The bottom layer represents impurities and precipitates, while the upper layer is filtered and then the solvent is vaporized. The effects of these solvents on properties were examined and evaluated.

e. Solvent Recovery

The solvent was stripped from the raffinate solution by distillation under a vacuum of about 5 mm Hg to avoid decomposition, and from the extract solution by atmospheric distillation. The raffinate and extract solutions were heated in the flask using a heating mantle with a regulator to control the heat supply as shown in Fig. **1**. The stripped raffinate was weighted and the raffinate yield was obtained.

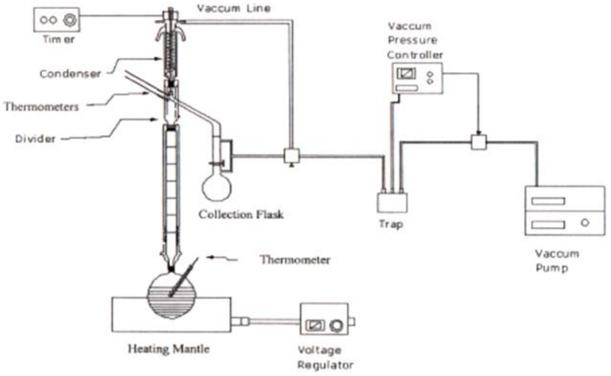

Fig. 1. Laboratory distillation unit

2.3. Test Methods

a. Specific Gravity

The specific gravity was estimated by the ASTM D941-55 method by the hydrometer device which was used for density measurement of the material to the density of the equal volume of water. The density was measured and recorded at standard conditions (15 ºC).

b. Viscosity

The viscosity of lubricating oil was estimated by the ASTM-D445 method.

c. Viscosity Index

The viscosity indexes of lube oil distillate fraction and raffinate oil were determined by the ASTM-D2270 method.

d. Ash Content

Ash content has been tested (ASTM D482-03). After a cooling step, they used sulphuric acid to process the ash content (sulphated ash), and then the ash was warmed to 780 ^{o}C. At this degree, a constant mass was obtained. Ash remained weighted in the final stage.

e. Flash Point

For flash point measurement by the ASTMD92 method, 5 Cm^3 of lubricant oil was transported into a 50 ml measuring flask, and then a temperature measurement by thermometer was embedded. The heating source, an Abunsen burner, was placed beneath the flask. At specific times, to set the temperature, a flame was operated. Then a flash will appear on the face of the oil being tested at a specific temperature while the sample of oil is being heated in the flask.

f. Pour Point

The pour point was measured by the ASTM D97 method. 25 Cm^3 of the lubricant oil was placed in a vessel. The lubricating oil was placed in a cooling bath medium, and a specific paraffin wax crystal was formed. If the oil sample does not flow when inclined, it is held horizontally in the container for 4–5 seconds to witness the movement of the surface sample. Continuous chilling was done till the sample stopped flowing. At this point, the temperature had reached a "pour point temperature."

3- Results and Discussion

3.1. Specific Gravity

Specific gravity is very impacted by the chemical constituent of the lubricating oil. The value of the specific gravity of used lubricating oil is much more than that of the virgin oil and the treated oil, This may be due to an increase in the quantity of the aromatic compound in the oil sample or high solids content present in the used engine oil, which led to the specific gravity is increased, while when saturated compounds increased, a decrease in the specific gravity was observed [23]. As shown in Table **2**, the values of specific gravity for virgin oil are 1.0035, and this value is low compared with the value of used lubricating oil which is 1.1052.

The rising value of specific gravity for utilized lubricating oil is because of the existence of contaminations such as solids, metals, or oxidation products. The efficiency for both solvents is closed to the specific gravity. The specific gravity of 2-Propanol solvent is more efficient than heptane on oil's specific gravity, resulting from treatment by the ratio (1:6) (1.063), which is very acceptable as closed to the specific gravity of virgin oil (1.0035), which means low contaminations and metals.

Table 2. Physical characteristics of treated lubricating oil

No.	Solvent type	Solvent / Utilized oil	Viscosity @40 ºC (cSt)	Viscosity @100 ºC (cSt)	Viscosity IndexVI	Specific Gravity
1	heptane	1:2	42.8	8.7	110.163	1.101
2	heptane	1:4	39.7	7.9	109.843	1.081
3	heptane	1:6	37.3	6.3	107.779	1.069
4	heptane	1:8	33.9	5.8	107.599	1.095
5	2-propanol	1:2	40.9	9.5	109.573	1.102
6	2-propanol	1:4	37.6	9.2	108.564	1.087
7	2-propanol	1:6	34.4	7.9	107.496	1.063
8	2-propanol	1:8	33.3	7.1	107.501	1.091

3.2 Viscosity

Viscosity is a very important consideration in the characteristics of fluids and lubricating oils. It’s classified as a state function and depended on temperature, pressure, and density. The relationship between viscosity and temperature is an inverse connection, so, when the temperature of the lubricating oil decreases, the viscosity increases, and vice versa. The friction between layers, or the oil film strength, is just about congruous to its viscosity. So, when rising the value of the viscosity, means the stronger the lubricating oil film. Raising or lowering in values of viscosity can happen because of the presence of contamination compounds, oxidation, or insoluble fuel [24]. Commonly, the higher viscosity of diesel engine oil compared with the gasoline engine is due to the light compound in gasoline engine oil, several problems might arise in working, like that heat generation from inner liquid friction, and definitely, the heat is influenced to the life of oil [25].

The results of viscosity show that the increases in values of used lubricating oil, because of polymerized compound oxidized products which dissolved and suspended in the oil, the high value in viscosity indicates the presence of pollutants. The oxidation of working oils is increased dramatically and generates produce deposits of corrosive oxidized products leading to increased viscosity [26]. For different solvents, the viscosity with four S/O ratios is shown in Table **2**. Viscosity at 40 °C was affected by heptane, and there was an improvement in viscosity characteristics, with the best value at a (1:8) ratio (33.9 cSt). A similar outcome was predicted at 100 °C (5.8 cSt).

However, while the viscosity of the treated oil was more significantly impacted by the 2-propanol solvent at 40 °C (33.3 cSt), and also at 100 °C the value was (7.1 cSt). This is a result of pollutants and degraded materials. At the point when the treated oil is seen, there is a contrast between the utilized, treated, and virgin oil. The viscosity of lubricating treated oil, for example at the ratio 1:2 in Table **2**, the viscosity is 42.8 cSt with heptane and 40.9 cSt with 2-Propanol at 40 °C. This means the two methods are degraded materials and impurities are removed and effective in eliminating or eliminating the oxidized products and deposits from the utilized oil [27].

This may likewise mean eliminating the added substances that have been added to upgrade viscosity.

3.3. Viscosity Index

The Viscosity Index is an experimental value, and it is the most important property of lubricating oil that reflects the range of the effect of the viscosity of lubricating oil upon the temperature change. A high viscosity index lubricating oil is preferred because it has excellent lubrication efficiency and low consumption when in use, as opposed to low viscosity index oil [28].

A rise in viscosity index demonstrates a little variation in viscosity with temperature, which additionally implies a good assurance of an engine that works with tremendous temperature varieties. Improvers in viscosity index are between the normally added substances that enhance oil efficiency. A high value in viscosity index is because of a shortfall of volatile and aromatic compounds. It additionally implies and low-temperature flow behavior and great thermal stability [29].

Both solvents in Table 2 have fundamentally the same effectiveness when added to the used oil for both solvents on the viscosity index. Table 2 indicates that for the treated utilized oil, the viscosity index with heptane 107.599 at the ratio of 1:8 veered off marginally from that of the utilized oil, 107.43. This shows the least negative impact 2-propanol has on the viscosity index enhancing added substances. It likewise appears to be that the two solvents added to a decrease in the viscosity index that was measured.

3.4. The Flash Point

The flash point is characterized by engine oil and it indicates the most minimal temperature of the oil which should be warmed to give off adequate vapor, forming a mixture with air that ignites immediately by a particular flame under indicated conditions.

The purity of the engine oil and the percent of oil contamination indicate the flash point. A considerably, so, the lowest value of flash point in engine oil is a credible point that the contaminated oil has become volatile with products such as gasoline. Due to the increased molecular mass of the oil, this is led to an increase in flash point.

The arrangement of volatile components as a result of oxidation would prompt a decay in the flash point [30]. Fig. 2, shows the flash point values of two solvents at a law solvent/oil ratio, shows a diminishing in flash point values in comparison with the fresh or at high ratios.

Different additives show improving its flash point 292 °C, which contribute with fresh oil to enhance the flash point. Surprisingly, the flash point measured on the oil sample is 268 °C. This flash point reduction is a consequence of contamination with oxidizing products. On the other, the flash point of the fresh oil clearly shows that is exceptionally impacted by 2-propanol as shown in the figure.

Then again, it is somewhat less impacted by adding heptane and 2-propanol, which elucidate the negative and complex impact of 2-propanol even on base oil. The flash point of the fresh oil is raised by utilizing heptane treatment [31].

That implies there is fuel contamination in the oil. Also, at the high temperature, it very well may be because of the existence of light cuts in oil while going through burning and oxidation in the burning engine. During that process, the oil is destructive into ingredient parts, which incorporate several light ends [32].

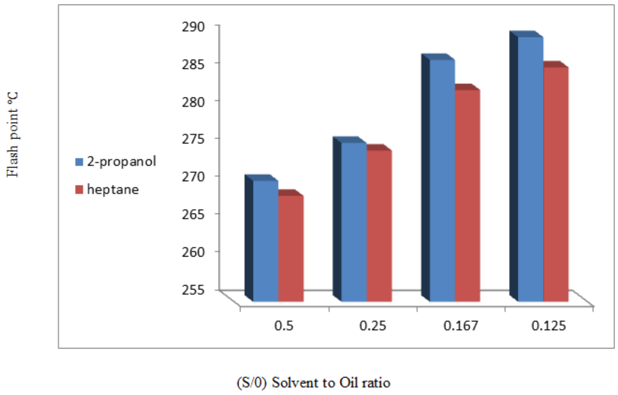

Fig. 2. The effect of the solvent to oil ratio on each solvent's flash point

3.5. Pouring Point

The most important characteristic of lubricating oil is pour point of engine oil, which is indicated to stay in a streaming state at the lowest temperature, in generality engine, virgin oils contain paraffin and waxes that thicken at low temperatures. High paraffin and wax content in engine oils led to an elevated pour point. The oil's viscosity is very affected on pour point, and at high viscosity. The engine oil pour points are described by their high pour points. It was identified as a significant variable, particularly when cold weather turns over the engine. Even at low temperatures, the oil should stream through the pump of oil and then be pushed out to the other engine parts [33, 34]. Fig. **3** shows the pour point values of two solvents.

Base oil pour point was not significantly affected by the addition of heptane. At first, the pour point changed by about 1.2 degrees Celsius, when 2-propanol was added, the temperature rose to 3.5 °C, the result of heptane additives to the oil solvent is necessary before the oil.

Fig. 3 shows the high effect of the (S/O) solvent to oil ratio on the pour point of solvents for used generator oil. This is a result of the declination of additives in lubricant oil. Pour point, specifically, is significant when oil should be put away in generally cool conditions [35].

The point changes broadly depending on the base oil and its sources, and the refining technique, particularly if at the end or finishing dewaxing [14]. When working lubricant oils are used with time, the aliphatic chains attached to the aromatic compound's ring are cracked and separated as a result of oxidation [36]. As shown in Fig. 3, the pour point of treated oils decreases as the solvent to oil ratio increases.

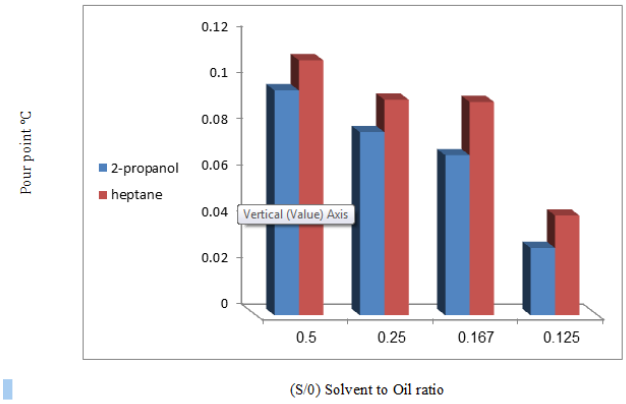

Fig. 3. The effect of the solvent to oil ratio on each solvent's pour point

3.6. Ash content

From Figure 4, it was found that 2-propanol was the most suitable for solvent extraction. Ash content is the content of the material non-organic mineralization in oil.

The ash content of utilized oil is high (1,174) as a result of the presence of minerals. Its sources are different, such as pollution, rust, and rust metals, which are produced by friction or corrosion of the engine conductors during operation, such as pistons, cushions, etc., or may result from dirt leaks or additive residues.

With this deduction, the ash value decreased to 0.029% at a high ratio of 1:8 for 2-Propanol, while for heptane the minimum value was 0.043% due to the disposal of existing metals, which is very close to the ash percentage of fresh oil (0.00), and the maximum value was 0.097% for 2-Propanol, while the maximum value for heptane was 0.11% at a ratio of 1:2.

The highest ratios are 1: 8, as ash content has minimum values. This was due to the fact that an excessive amount of work had been done to dissolve some existing pollutants [37].

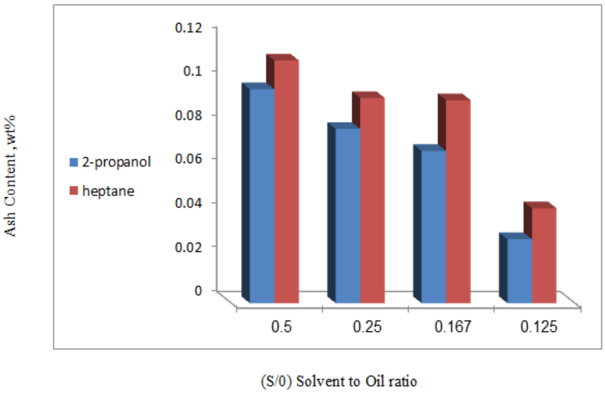

Fig. 4. The effect of the solvent to oil ratio on each solvent's ash content

3.7. The effect of extraction temperature

Fig. **5** shows the effect of the temperature on a raffinate yield at a range from 30 °C to 60 °C (lubricating oil yield), temperature parameter represents the important factors influencing the overall efficiency and performance of the extraction process, the experimental test of the sample was tested at solvent/oil ratio (1:6). The maximum percentage yield of 2-propanol is approximately 92% at 40 °C, while heptane is 84% at 50 °C. At these temperatures, the aromatic compounds' solubility in the solvent results in a drop in extraction efficiency, so good solvent power is another essential advantage that a solvent contains aromatic compounds and their related pollutants [38]. Solvent power is probably going to indicate the solvent's efficiency in extraction process relatively at a low volume. Power solubility in many cases increases with temperature at almost, this is may be damage of the selectivity, so, at elevated temperature, when the temperature rises, the development of aromatic compounds necessitates a higher solubility with the lubricant oil, and this is important target [39]. Likewise, the dissolving of the target undesirable composition is very low at low temperatures in any of the three solvents because the contaminants and heavy residual aromatics do not completely separate, and the ability to extract chemical contaminants becomes higher due to an increase in solubility and affinity [40].

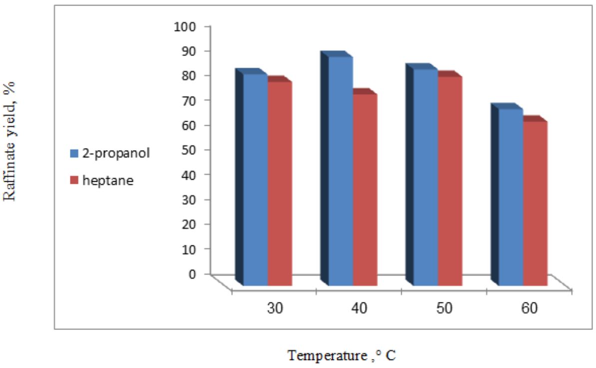

Fig. 5. The effect of the temperature on each solvent's raffinate yield percent

4- Conclusions

In this research, the capacity of the solvent extraction method to refine the utilized lubricating oil was shown to be improved by this research. Two types of solvents are employed (heptane and 2-propanol). From the outcomes acquired, the solvent/oil ratio and temperature were very affected on the characteristics and quality. There should be a compromise to be made in operating the process of extraction at the best lower solvent to oil ratio and temperature to minimize cost if the results from this study were scaled-up to an industrial scope for a wider range of applications. This normally needs particular enhancement and optimizing the results of studies. 2-propanol efficiency is better compared to heptane according to the values of characteristics. Although 2-propanol further enhanced the viscosity index of the utilized lubricant oil, the extraction method is powerful in eliminating pollutants as they improve the properties of the treated oil: viscosity, specific gravity, pour point, flash point, and ash content. Besides, the results show also that when the temperature increases, according to the raffinate yield the quality of the oil is improved at up to 40 °C for 2-propanol and 50 °C for heptane.

References

[1] Munirah Abdul Zali, Wan Kamaruzaman Wan Ahmed, Ananthy Retnam, Ngcatina,*"Concentration of heavy metals in virgin, used, recovered and waste oil: a spectroscopic study"*, Proc. Environ. Sci. 30, 2015,PP.201-204.

[2] C.Y. Foo, M.Y. Rosli, S.S. Tea, *"Modeling and Simulation of Used Lubricant Oil Re– Refining Process"*, Second World Engineering Congress Sarawak, Malaysia, 2002.

[3] R. Abu-Elella, M.E.Ossman, R.Farouq, M.Abd-Elfatah, *"Used motor oil treatment: turning waste oil into valuable products"*, Int. J. Chem. Biochem. Sci. 7, 2015, P.P. 57-67.

[4] F. Danane, A.Ahmia, A. Bakiri, N. Lalaoui, *"Experimental regeneration process of used motor oils"*, Rev. Des. Energies Renouvables 17 (2), 2014, P.P. 345-351.

[5] I. Hamawand, T. Yusaf and S. Rafat, *"Recycling of Waste Engine Oils aNew Washing Agent"*, Energies ,Vol. 6,No.2,.2013. p.p.1023-1049.

[6] M. k. Jha, *"Re-refining of used lube oils: an intelligent and ecofriendly option"*, Indian Chemical Engineering, vol. 473, 2005. pp. 209- 211.

[7] F. O. Cotton, *"Waste lubricating oil: an annotated review"*. REVISION DEB3001439 of Annotated Review 1997 BETC/IC 79/4, CORP; Source- Department of Energy, Bartlesville, Okla, USA, 1997.

[8] T. Bhaskar, M.A. Uddin, A. Muto, Y. Sakata, Y. Omura, K. Kimura, Y. Kawakami,*"Recycling of waste lubricant oil into chemical feedstock or fuel oil over supported iron oxide catalysts"*. Fuel 83 (1), 2004, P.P.9-15.

[9] A.Hamad, E. Al-Zubaidy, and M. E. Fayed, *"Used lubricating oil recycling using hydrocarbon solvents"*, Journal of Environmental Management, vol. 74, no. 2, 2005pp. 153–159.

[10] Nancy Zgheib and Hosni Takache *" Recycling of used lubricating oil by solvent extraction: experimental results, Aspen Plus simulation and feasibility study"* Clean Technologies and Environmental Policy, 2020 | Original Paper | Issue 1/2021,p.p 1-12.

[11] A. Kamal, F. Khan, *"Effect of extraction and adsorption on refining of used lubricating oil"*, Oil Gas Sci. Technol. 64 (2), 2009, p.p.191–197.

[12] K. O. Boadu , O. F. Joel1, D. K. Essumang2 and B. O. Evbuomwan," *A Review of Methods for Removal of Contaminants in Used Lubricating Oil"* 26(4): 1-11, 2019; Article no.CSIJ.48620,p.p.1-11.

[13] Khudhair, M.M.; Abas K.F.; Hameed, T.M.," *Recycling of Used Generator Oils by Different Treatment Methods* ", J. Petro. Eng. Techn. 2(3), 2012, P.P. 29-41.

[14] J. D. Udonne, *"A comparative study of recycling of used lubrication Oils using Distillation, acid and activated charcoal with clay methods"*, Journal of Petroleum and Gas Engineering, vol. 2, no. 2, 2011, pp. 12–19.

[15] A. Hamad, E. Al-zubaidy, M.E. Fayed, *"Used lubricating oil recycling using hydrocarbon solvent"*, J-Unviron. Manage. 74 , 2005,P.P. 153-159.

[16] J. Sauners, *"Used oil refining revolution"*, Lubricants World 6 (9), 1996, P.P. 20-24.

[17] N.O. Elbasshir, *"The Effect of Design Parameters on the Solvent Extraction Performance for Recycling of Used Oil "*, M.Eng. Thesis, Thesis University of Technology Malaysia, 1998.

[18] J.H. Sherman, *"Removal Transition metals from motor oil using ion exchange resins"*, Environ. Technol. 14 (11), 1993, P.P. 1097-1100.

[19] M.I. Abdul_Mutalib, N.O. Elbashir, M. Sahrif, R. Adnan, *"Practical use of the solubility parameters in determining effective solvent extraction parameters for recycling used lubricating oil"*, proceedings of RSCE98, Manila, Philippines, 1998, pp. 110-117.

[20] J.L. Assuncao Filho, I.G.M. Mora, A.C.S. Ramos, *"Liquid –Liquid extraction and adsorption on solid surfaces applied to used lubricant oils recovery"*, Braz. J. Chem. Eng. 27, 2010, p.p. 687-697.

[21] H.A. Durrani, M.I. Panhwar, R.A. Kazi, *"Re-refining of waste lubricating oil by solvent extraction"*, Mehran Univ. Res. J. Eng. Teach. 30 (2), 2011, p.p. 237-246.

[22] Shri, K.C.; Mohan, K.S.;Sakeer, H.M.;Deepa ,P.N.; Sara, V.K.,*"Studies on Reuse of Re-Refined Used Automotive Lubricating Oil"*, J. Eng. Sci.3(6) , 2014, p.p. 8-14.

[23] Forsthoffer, W.E. *"Lube, seal and control oil system best practices"*. In Forsthoffer's Best Practice Handbook for Rotating Machinery, 1st ed.; Elsevier: Oxford, UK, 2011; pp. 347–468.

[24] Tran T. N. and Roman M. B. *"Determination of metals in lubricating oil by ICP-AES"*, Instruments Work, Vol. 2, 1991, p.p. 1-5.

[25] Jose C. Velasco-Calderon, José Luis Lopez Cervantes, Arturo A. Garcia-Figueroa, and Jesús Gracia-Fadrique *" Regeneration of used lubricating oil by solvent extraction and phase diagram analysis"* Current Research in Green and Sustainable Chemistry 3 ,2020, p.p. 1-6.

[26] Scapin MA,*"Recycling of used lubricating oils by ionizing radiation process"*, Radiation Physics and Chemistry, Vol.76, Issues 11–12, November–December 2007,p.p. 1899-1902.

[27] Doaa I.Osman, Sayed K.Attia and Afaf R.Taman, " Recycling of used engine oil by different solvent", Volume 27, Issue 2, June 2018, p.p. 221-225.

[28] C.J.A. Roelands, *"Correlational Aspects of the Viscosity-Temperature-Pressure Relationship of Lubricating Oils"*, 1966.

[29] R.M. Mortier, M.F. Fox, S.T. Orszulik, eds., *"Chemistry and Technology of Lubricants"*, Springer Netherlands, Dordrecht, 2010.

[30] J. Rincon, *"Regeneration of used lubricant oil by polar solvent extraction"*, Industrial & Engineering Chemistry Research, vol. 44, no. 12, 2005, pp. 4373-4379.

[31] Firas A, Dumitru P *"Design aspects of used lubricating oil rerefining"*, 1st Edition - April 12, 2006. p.p. 114.

[32] Friday O.N., Bamidele I.O., Kayode O, A., Luter L; *"Comparative Investigation of Wear Metals in Virgin and Used Lubricant Oils"*, Terrestrial Aquatic Environmental Toxicology, 2(1), 2008.p.p.38-43.

[33] Riazi, M.R.; Daubert, T.E. *"Predicting flash and pour points"*. Hydrocarb. Process. 1987, 66, p.p. 81-83.

[34] Burrows J. A. , Heerdt J. C. , Willis J. B. ; *"Determination of Wear Metals in Used Lubricating Oils by Atomic Absorption Spectrometry"*. Anal. Chem., 37 (4), I965, p.p. 579-582.

[35] Speight, J. G., and Exall, D. I., *"Refining used lubricating oils*. CRC Press, Taylor & Francis Group, Boca Raton, Florida. 2014,Ch. 1,2,4 and 7.

[36] Mahmood, S. M., MSc. Thesis, *"Study the effect of different working variables on the re-refining used lubricating oil and reduced the environmental conditions"*. University of Al-Nahrain, Chemical Engineering Dep. 2015.

[37] J.P. Wauquier, P. Trambouze, J.P. Favennec, *"Petroleum refining"*. Editions Technip, 1995.

[38] A.-H. A. Mohammed and M. J. Yass Kheder, "The Effect of Extraction Temperature and Solvent to Oil Ratio on Viscosity Index of Mixed-medium Lubricating Oil Fraction by Using Solvents Extraction", *IJCPE*, vol. 10, no. 2, pp. 13–18, Jun. 2009.

[39] S. Al-Zahrani, et al., *"Used lubricating oil regeneration by various solvent extraction techniques"*, J. Ind. Eng. Chem. 19 (2013) 536–539.

[40] R. F. Abdul-saheb and M. A. Mohammed, "A Comparative Study of the Influence of Different Types of Polymers on Viscosity Index and Pour Point of Iraqi Base Oils", *IJCPE*, vol. 20, no. 3, pp. 7–13, Sep. 2019.

معالجة زيت الوقود المستخدم بالفصل بالمذيبات

طارق محمد نايف[1] و سرمد عبدالرزاق رشيد[1] و مروة فائق عبدالجبار[3]

[1] جامعة بغداد– قسم الهندسة الكيمياوية
[2] جامعة النهرين – قسم الهندسة الكيمياوية

الخلاصة

تبحث هذه الدراسة في معالجة زيت الوقود المستخدم من شركة محطة كهرباء المسيب الغازية–العراق والذي تم معالجته بمذيبات استخلاصية مختلفة (هيبتان و 2– بروبانول). تم فحص وتقييم نشاط أداء هذه المذيبات في عملية الاستخلاص تجريبياً. متغيرات التشغيل كانت نسبة المذيبات إلى الزيت (1: 2 ، 1: 4 ، 1: 6 ، و 1: 8) ، زمن الخلط (20 ، 35 ، 50 ، 65 دقيقة) ، درجات الحرارة (30 ، 40 ، 50 ، و 60 درجة مئوية) ، وسرعة الخلط (500 دورة في الدقيقة). تم دراسة وتحليل هذه المتغيرات. تم تحديد الجودة من خلال قياس وتقييم الخصائص الهامة وخاصة اللزوجة ، مؤشر اللزوجة ، الكثافة النوعي ، نقطة الانسكاب ، نقطة الوميض ، ومحتوى الرماد.

اكدت النتائج أن المذيب (2– بروبانول) أعطى كفاءة عالية مع أعلى نسبة من إزالة الحمأة مقارنة بالهبتان. وجد ان تحسين أكبر نسبة لإزالة الحمأة كانت عندما تزداد نسبة المذيبات / الزيت مع الاخذ بالجوانب الاقتصادية للنسبة المثلى.

تم دراسة الخصائص الهامة لزيت الوقود المعاد استخدامه. تشير النتائج إلى أن تحسين خصائص الزيت المعاد استخدامه له فعالية كبيرة وأفضل ظروف عمل لـ 2– بروبانول كانت عند (35 دقيقة ، نسبة المذيب/ الزيت 1: 6، 40 درجة مئوية) ، وللهبتان (50 دقيقة ، نسبة المذيب/ الزيت 1: 6 و 50 درجة مئوية).

الكلمات الدالة: زيت الوقود المستخدم، خصائص زيت الوقود و استخراج المذيبات.