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Treatment of Reused Oil by Thermal Conversion Process

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Abstract

This work deals with treatment ofused lubricant oils whichare accumulate from automotive engine, bythermal conversion process. The used lubricant oil for two samples is fractionated by the atmospheric distillation device into fractions, (waste oil liquids and residue). Which are carried out at atmospheric pressure and temperature up to 350 ºC.

The conversion which was obtained from these fractions was (92 and95) % respectively for these two samples.

The fractionated waste oil liquids products fromatmospheric distillationdeviceare fractionated alsoto light fractions (gasoline, kerosene, gas oil) and residue for these two samples at atmospheric pressure according to their boiling point.These fractions for these two samples are also distillated inatmospheric distillation device, in order to calculatesome important physical and chemical properties (Mean average boiling point, specific gravity, flash point, aniline point, smoke point, molecular weight) of these fractions, to comparison with standardphysical and chemical properties, alsostudying the possibilities of industrial uses for these fractions.

The yield of gas oil for the first samplein waste lubricant oilisabout 50%, more than gasoline 15% and kerosene 30%from 100 ml of treatment waste lubricant oil, and more identical curve from gasoline and kerosene curve.

Also for the second sample, the yield of gas oil is the largest quantity 43%fromtheyield of gasoline 15% and yield of kerosene 35% from 200 ml of treatment waste lubricant oil, and more identical curve with kerosene from gasoline curve.

Key words: Thermal treatment of used lubricant oils

*ASTM – D86 (American Society for Testing and Materials)

1- Introduction

Automotive lubricating oils play a most vital role in our great complex civilization. To estimate the importance of its role one need only consider that every moving part of every machine is subjected to friction and wear. Lubricating oils are viscous liquids used for lubricating moving part of engines and machines [1]

Friction consumes energy; wear causes changes in dimensions and eventual breakdown of the machine. To overcome this problem, lubricating oil is used to reduce friction, protect against wear, carry away heat, protect against rust and remove contaminants from the engine.[2]

This lubricating oil is made from crude oil after refining by introducing proper additives and its sources and reserves are limited and are not inexhaustible throughout the world.

The used oil loses its effectiveness during operation due to the presence of contaminants. This oil is less subject to biodegradation and does not evaporate but becomes contaminated with substances that are hazardous to human health and the environment, so before it can discharged to the environment this oil requires suitable collection and treatment.

The hazardous nature of waste oils (used oils) makes their proper handling, treatment, and disposal imperative. Increases in the number of motor vehicles and the spread of various types of industrial processes to a greater number of communities necessitate wider dissemination of accurate and practical knowledge regarding their recycling and disposal.[3]

A large range of waste oils can be recycled and recovered in a variety of ways, either directly or after some form of separation and refinement. In keeping with the waste management hierarchy, the first option is to conserve the original properties of the oil, allowing for direct reuse. Other options include recovering its heating value and/or using in other lower-level applications. Certain types of waste oils, lubricants in particular, can be reprocessed. Allowing for their direct reuse. After treatment, waste oils can be used either as lube base stock comparable to refined virgin base oil or as clean burning fuel. Waste oils and residues from recycling processes which cannot be reused in any way need to be disposed of in an environmentally sound manner [1].

Thermal cracking reactions are those that occur when the temperature is raised (460-540 ºC) to a point at which the bonds that hold a molecule together are broken. This breaking of bonds results predominantly in an increase in smaller molecules.

However breaking of bonds also leads to free radical formation, which can also result in subsequent polymerization or condensation reactions. [1]

The rate of a reaction grows with elevation of the feed stock boiling point. This feature is explained by the different thermal stability of hydrocarbons. High-molecular alkanes and also arenes with a long side alkyl chain are less stable thermally than low molecular weight hydrocarbons. Hence, less decomposition products will form when the later are cracked.

Feed stock containing mainly alkanes is preferable for thermal cracking plants because they decompose more readily with the formation of target products such as gas, gasoline, and middle distillate,as the same time a little coke forms in the de composition of this kind of stock. The formation of coke in thermal cracking is known to be undesirable because it affects the duration of continuous running of the plants. Owing to the accumulation of coke in the furnace coil, thermal cracking plants have to be shut down for burning out the coke [4].

The fraction boiling at 200-350ºC is called thermally cracked gas oil it is used as a component of bunker, gas turbine sand furnace fuels. After hydrofining, the gas oil can be used in diesel fuel production.

Cracking residue is the fraction boiling above 350ºC. The quality of the cracking residue as a furnace fuel is higher than that of the straight run stock because the cracking residue has higher enthalpy (heat content) and a lower pour point and viscosity. This facilitates the transportation of furnace fuels through the system of feeding pipe lines and their atomization in the nozzles [2].

The thermal cracking of petroleum fractions is a very involved chemical process. The feed stock consists of a large number of individual components. [5]

It is impossible to predict or follow the fate of each of these components under the action of high temperatures. The main kind of thermal cracking for hydrocarbons in cracking of alkanes is decomposition at a C-C bond with the formation of an alkane and an alkene.[6]

More scientists consider that the thermal cracking of alkanes are of a chain nature and observe the free radical theory. The reactions of free radicals are fast, indeed only one radical is sufficient to being about a series of reactions. [7]

The steps involved in thermal cracking reaction are: initiation, propagation and termination [5, 6].

Products of cracking have different properties because of unsaturation. These properties are entirely dependent upon the conditions of the cracking. Some of the properties of the cracked products are very much different from the parent substance.Treatment of used lubricant oil by thermal conversion processes device can get light fractions (gasoline, kerosene, gas oil) and residue.[8]

The **gas** of thermal cracking contains alkanes (from methane to butane) and alkenes (from ethylene to butylene), hydrogen and hydrogen sulphide. The ratio of the gas components depend on the temperature and pressure of the process.

The **gasoline** produced by thermal cracking differs in their hydrocarbon composition from the straight-run ones. The latter mainly contain alkanes and cycloalkanes, while the cracked gasoline contains many unsaturated and aromatic hydrocarbons. Thermally cracked gasoline used at present as a component of low octane motor fuels. The octane number of cracked gasoline is usually higher than that for straight run gasoline.

2-Experimental work

2.1-Material

In the present work it was used two samples of used oil in cars (2000km. and 4000km.)

2.2- Procedure:-

1. Feed 100 ml of used lubricant oil (2000 km.) (Sampleno. 1)in atmospheric distillation device and running the process until first drop down, record the initial boiling point.Continue the distillation and record the temperaturesfor (5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85,90 and 95) ml. of distilled fraction and finely calculate the true boiling point from ASTM D-86device. Asshown in figure 1.
2. The used lubricant oil distilled, re-feed againby ASTM D-86 device unit to fractionated it to light fractions (gasoline-kerosene-gas oil) according to boiling point. As shown in figure 1.
3. Each of three fractions(gasoline-kerosene-gas oil)get from step two are fed to ASTM D-86 unit to get ASTM distillation curve, for measuring the chemical and physical properties of each fractions are shown in Table -1.
4. Repeat these procedures on second sample 200 ml of used lubricant oil (4000 km.)

Figure 1: Atmospheric distillation unite according to ASTM D -86

3- Resultsand discussion

3.1- Material balance:-

3.1.1- Sampleno.1

The volume of used lubricant oil sample no.1 is (100) ml.

The volume of fractions (gasoline, kerosene, gas oil) which produced from cracking used lubricant oil sample no.1 by thermal conversionprocesses (ASTM D-86) are (15, 30 and 50) ml. respectively and 5% residue.

The conversion from used lubricant oil sample no.1 is 95% (light fractions only)

3.1.2- SampleNo.2

The volume of used lubricant oil sample no.2 is (200) ml.

The volume of fractions (gasoline, kerosene, gas oil) which produced from crackingused lubricant oil sample no.2 by thermal conversion processes (ASTM D-86) are (30, 70, 85) ml respectively and 15 ml. residue.

The conversion from used lubricant oil sample no.2 is92.5% (light fractions only)

3.2- Physical and chemical properties

The Physical and chemical properties for fractions which are obtained from cracking used oil samples were listed in Table 1 and compared with standard property fraction

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Table 1: The physical and chemical properties for fractions which wereproduced from used lubricant oils.

Property		Fractions produce from sample no. 1			Fractions produce from sample No. 2			standard property for fraction		
		gasoline	kerosene	Gas oil	gasoline	kerosene	Gas oil	gasoline	kerosene	Gas oil
Specific gravity.		0.74	0.78	0.8	0.75	0.8	0.83	0.72-0.77	0.77-0.82	0.82-0.86
API gravity.		59.72	49.91	45.375	57	45	39	50-60	40-50	35-45
Mean average boiling (°R)		645	869	974	756	867	1052	-----	----	----
Watson characterization factor.		11.68	12.23	12.4	12.14	12	12.25	11-13	11-13	11-13
Molecular weight.		93	167	214	126	165	252	115	170	225
Cetane Index.		74	52	61	46	54	57	Min.40	Min.45	Min.53
Diesel Index.		88.7	59.34	71.7	50	61	66	----	----	----
Aniline point (°C)		65	68	70	61	69	73	60	65	70
Viscosity at 100 °F (Cst.)		0.5139	1.3238	2.511	0.7281	1.4187	4.608	0.6	1.6	Max.5.6
Refractive	Experimental	1.4104	1.435	1.4456	1.4181	1.4458	1.4606	----	----	----
Index	empirical	1.4395	1.456	1.4877	1.4395	1.4565	1.4712	----	----	----
Pour point (°k)		167	219	245	189	225	267	Min.160	Min.220	Max.264
Smoke point in(mm)		------	27	-------	--------	25	------	----	Min.22	-----
Flash point(°k)		308	318	322	313	318	325	Min.305	Min.315	Min.327
Raid vapor pressure (bar)		0.55	-------	-------	0.62	------	------	0.45-0.84	----	----
Net heat value (MJ/Kg)		46.8	46	45.6	46.5	41.7	45	----	----	----

3.3- Results of (ASTM D-86 and True Boiling Point) curves forused lubricant oil

3.3.1- sample no.1

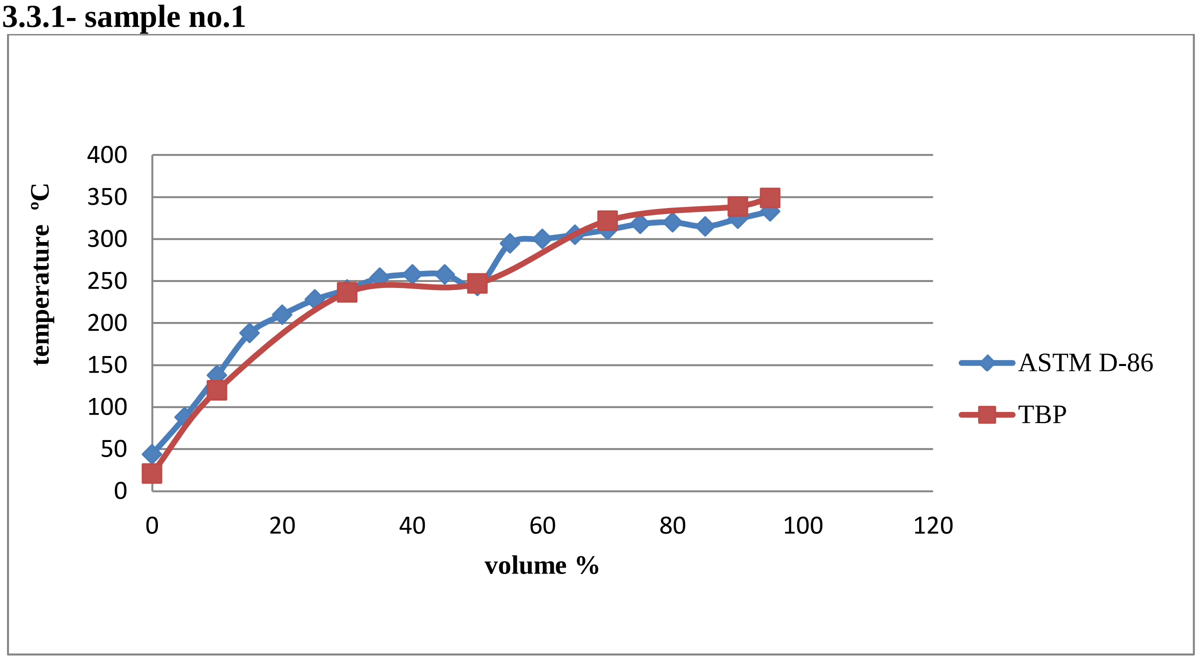

Figure 2: Atmospheric distillation (ASTM D-86 and TBP) for used lubricant oil sample no.1

This figure refer to atmospheric distillation curve for used lubricant oil sample no.1,Also refer to the fraction of gas oil is more in volumethan gasoline and kerosene is about 50 ml from 100 ml of usedlubricant oil, according to boiling point for fractions (70-170 ° C for gasoline), (170-250 ° C for kerosene) and (250-350 ° C for gas oil).

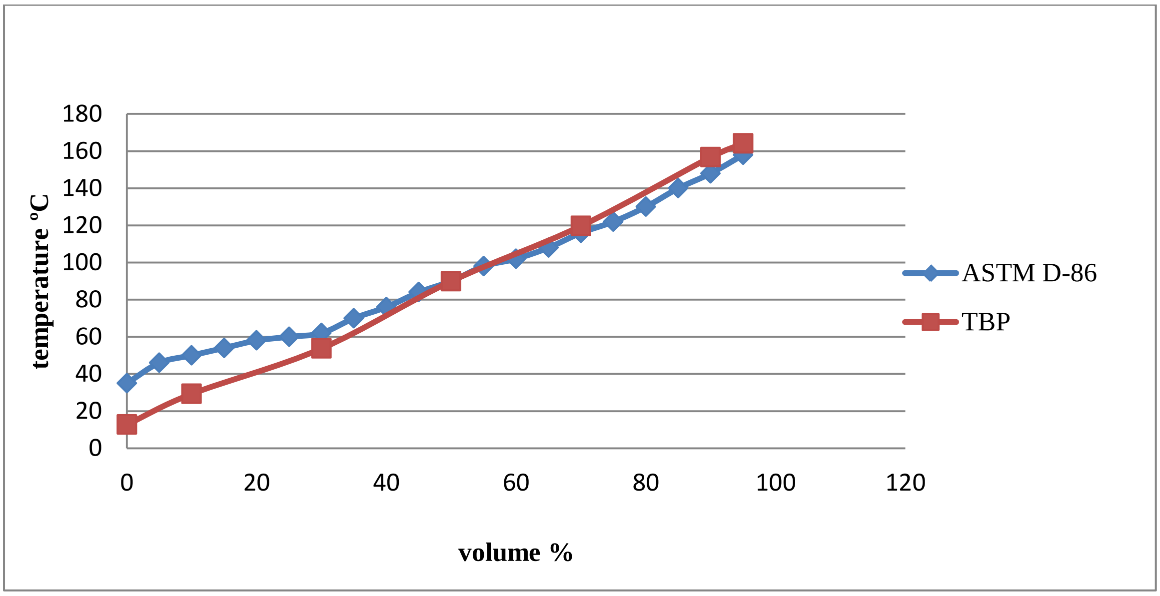

Figure 3: (ASTM D-86 and TBP)distillation for gasoline from used lubricant oil sample no.1

The gasoline which obtained by thermal treatment (70-170° C) for used oil have high octane number so, it is possible to use it, as a component for automobile gasoline production.

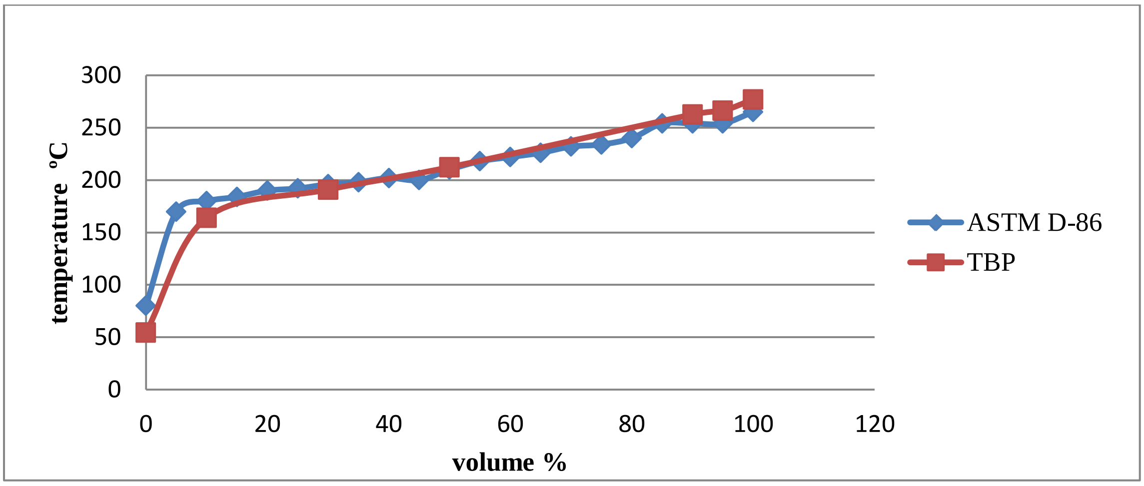

Figure 4: (ASTM D-86 and TBP) distillation for kerosene from used lubricant oil sample no.1

The kerosene which obtained by thermal treatment (170-250)° C for used oil have high smoke point so, it is use as a component for domestic kerosene production.

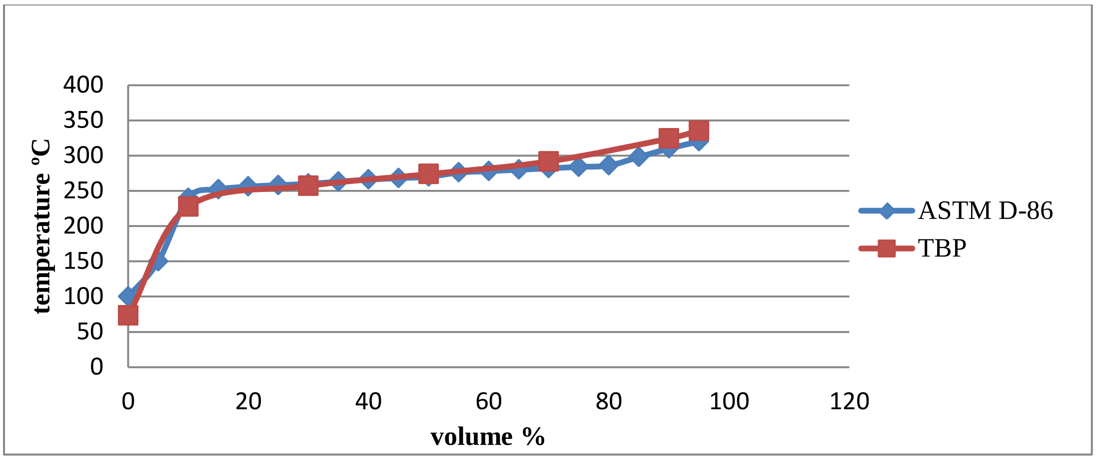

Figure 5: (ASTM D-86 and TBP) distillation for gas oil from used lubricant oil sample no.1

The gasoil which obtained by thermal treatment (250-350) ° C for used oil have high aniline point and diesel index so, it is use as a component for light diesel fuel and fuel oil production.

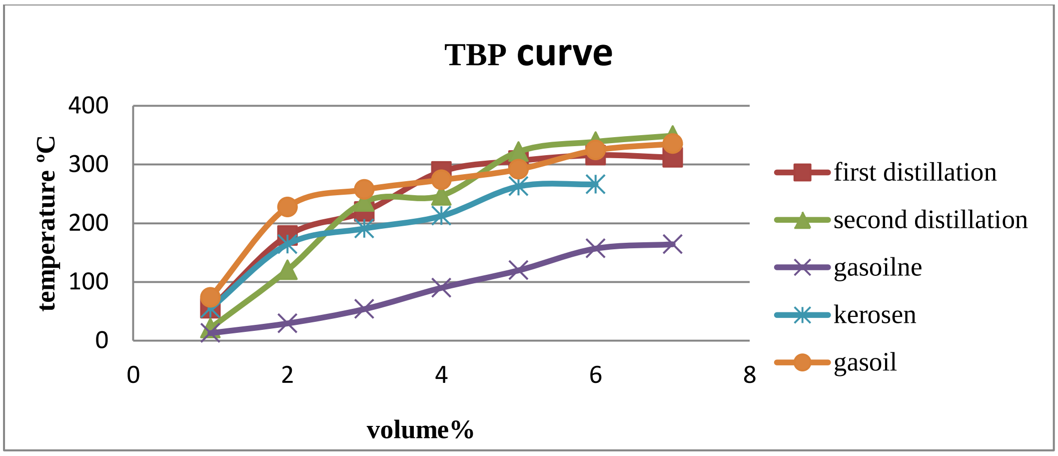

Figure 6: Compare between TBP curves for (first distillation, second distillation, gasoline, kerosene, gas oil) from sample no.1

The product of gas oil fromused lubricant oil sample no.1 ismore identical curve from gasoline and kerosene curve as shown in figure 6, also the physical and chemical properties of the fractions (gasoline, kerosene and gas oil) which were produced from used oil no.1, As shown in table-1, were more identical with that in standard properties .

3.3.2- sample no.2

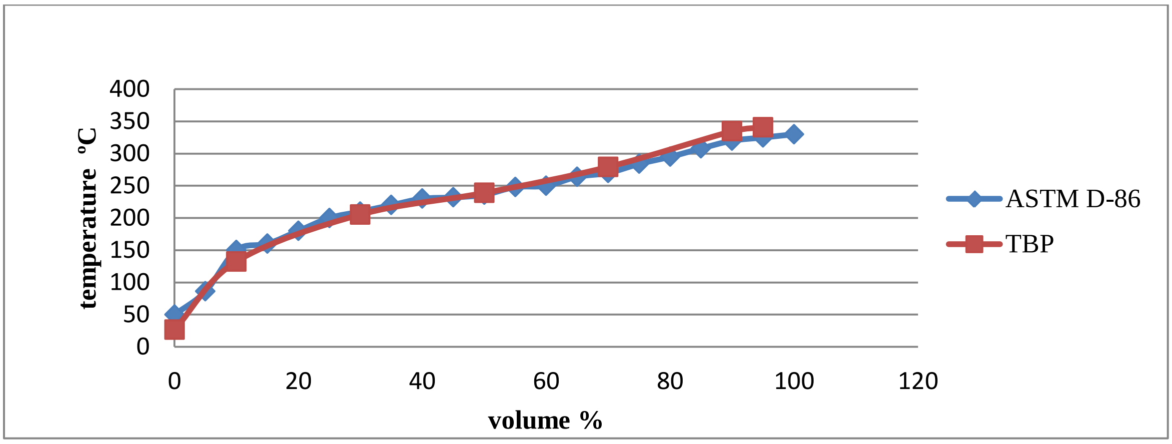

Figure 7: Distillation (ASTM D-86 and TBP) for used lubricant oil sample no.2

This figure refer to atmospheric distillation curve for used lubricant oil sample no.2,The volume of gas oil is the largest quantity from the product of gasoline and kerosene,according to their boiling point of fractions (70-170 ° C for gasoline), (170-250 ° C for kerosene) and (250-350 ° C for gas oil).

The physical and chemical properties of the fractions (gasoline, kerosene and gas oil) which were produced from used oil number -2,As shown in table-1, were more identical with that fixed in standard properties.

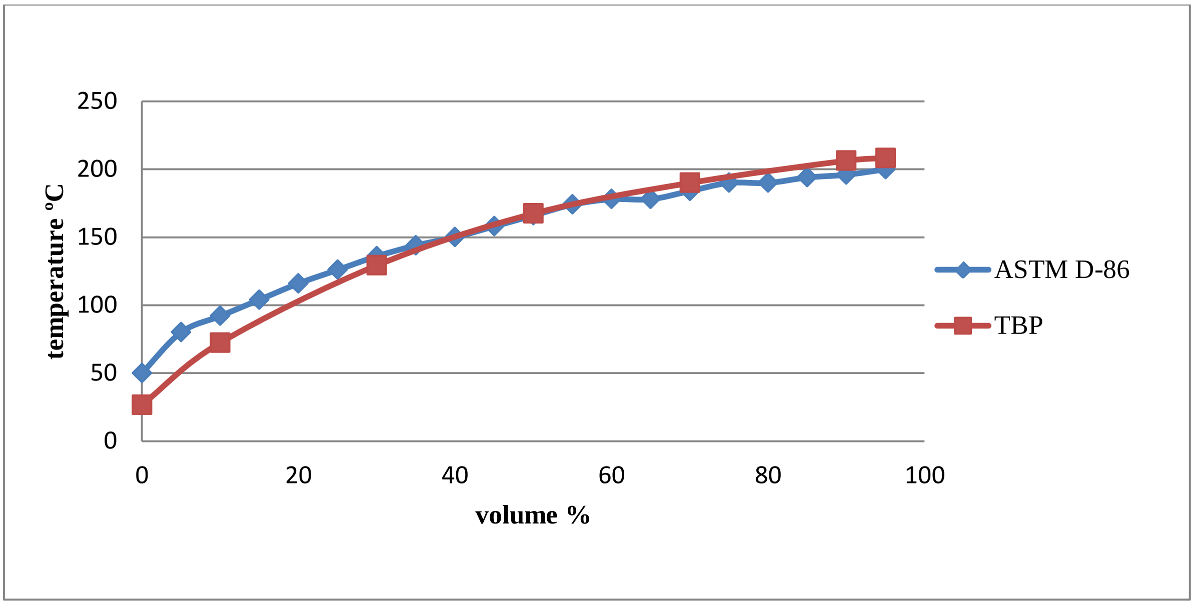

Figure 8: Distillation (ASTM D-86 and TBP) for gasoline produced from used lubricant oil sample no.2

The gasoline which obtained by thermal treatment (70-170) ° C for used oil have high octane number so, it is possible to use it, as a component for automobile gasoline production.

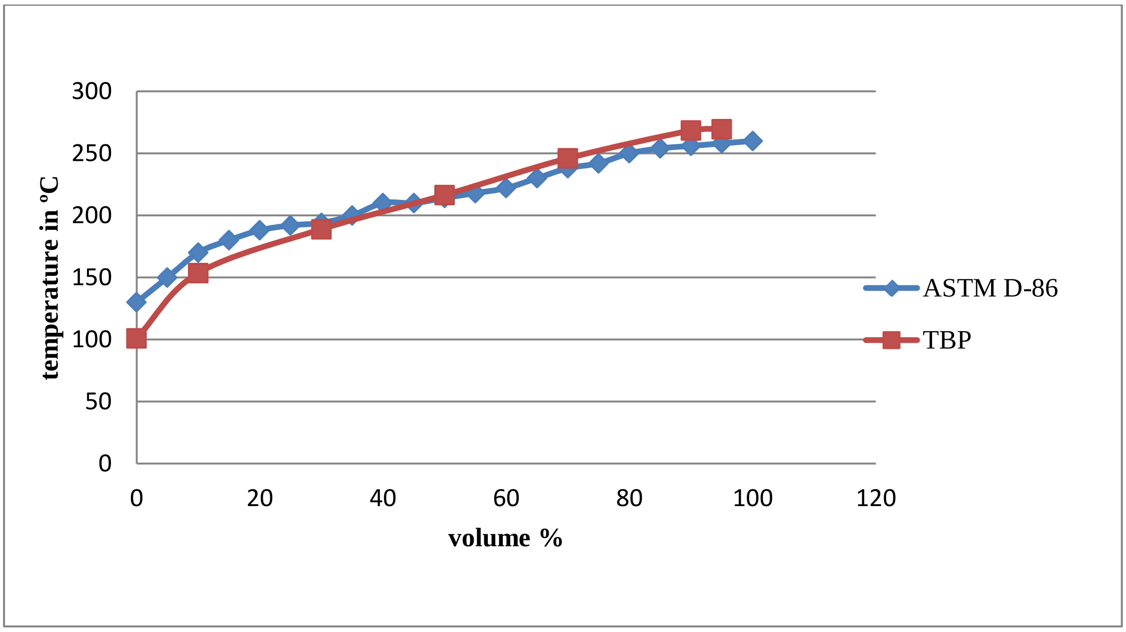

Figure 9: Distillation (ASTM D-86 and TBP) for kerosene produced from used lubricant oil sample no.2

The kerosene which obtained by thermal treatment (170-250) ° C for used oil have high smoke point so, it is use as a component for domestic kerosene production

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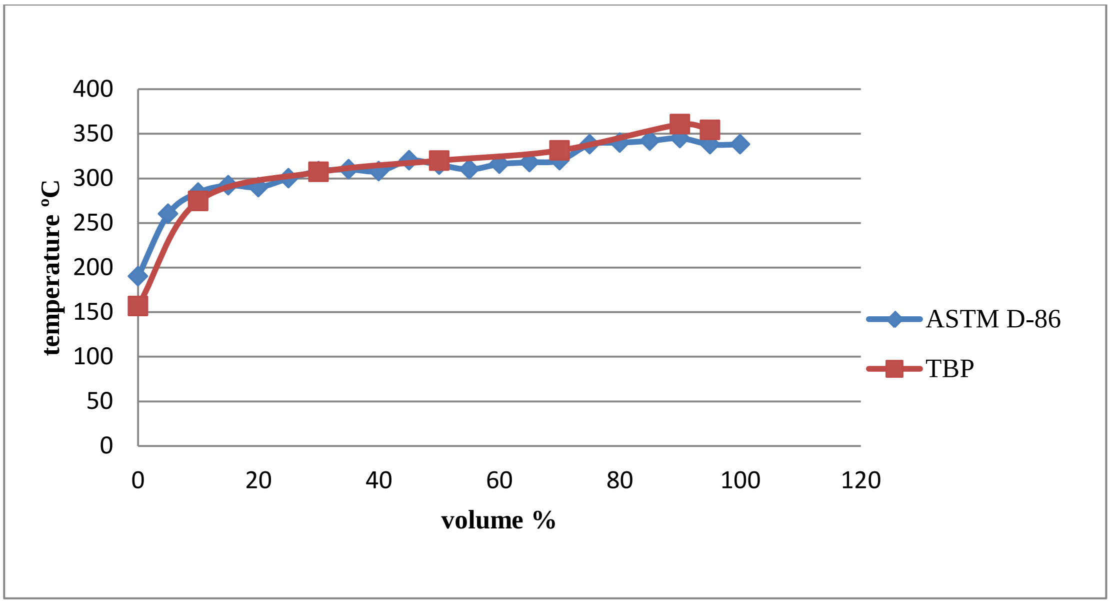

Figure 10: Distillation (ASTM D-86 and TBP) for gas oil produced from used lubricant oil sample no.2

The gas oil which obtained by thermal treatment (250-350) ° C forused oil have high aniline point and diesel index so, it is use as a component for light diesel fuel and fuel oil production.

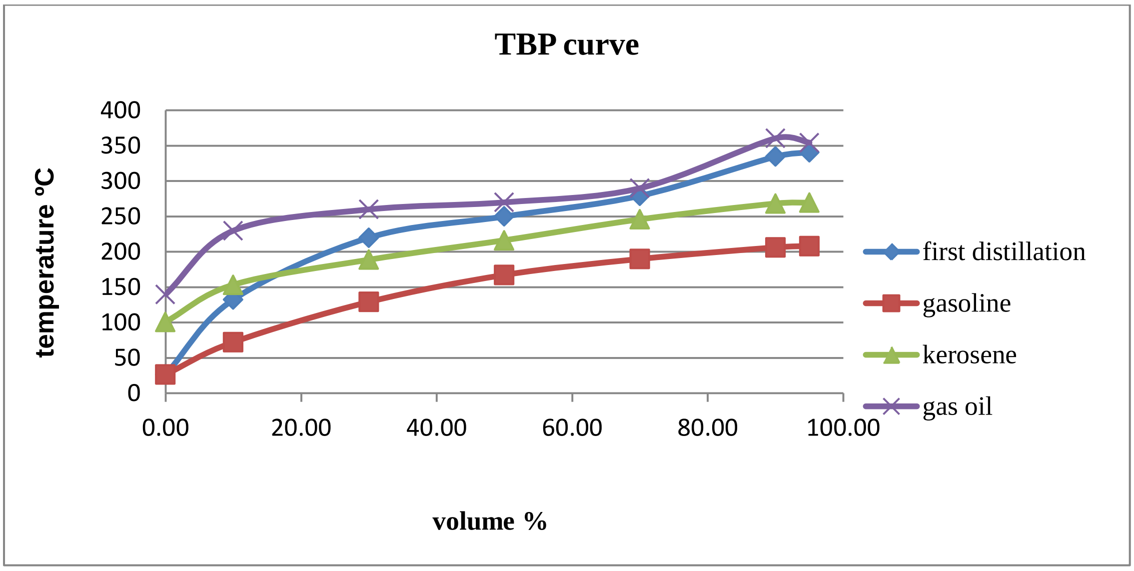

Figure 11: Compare TBP distillation curves between (first distillation, gasoline, kerosene, gas oil) for sample no.2.

The product of gas oil ismore identical curve with kerosene from gasoline curve for sample No.2 as shown in figure11,the physical and chemical properties of the fractions (gasoline, kerosene and gas oil) which were produced from used oil number -2, As shown in table-1, were more identical with that fixed in standard properties.

4- Conclusion:-

1- It was concluded that the possibility treatment of used lubricant oil which be used in variousvehicles (cars), marine and different industrial machines.
2- The reused oil will care and clean the environment protectionfrom pollution causes due to used oil toavoid the negative impacts on human health.
3- The advantages of this treatment is tofind a renewable energy in addition to crude oil, for economic purposes with high quality products.
4- It could produce light fractions (gasoline, kerosene, gasoil) from thisused oil with high conversion about to 95%.
5- The obtained light fractions (gasoline, kerosene, gasoil) classify with chemical and physical properties identical with chemical and physical standards (commercials) properties.
6- Possibilty uses these fractions for internal combustion engine as fuel (cars) or for domestic uses (kerosene) and diesel fuel for gas oil or fuel oil.

References:-

[1] United Nations Environment Programmer. Division of Technology, Industry and Economics International Environmental Technology Centre, Osaka, Japan (2012) "Compendium of Recycling and Destruction Technologies for Waste Oils" Copyright © United Nations Environment Programmer.

[2] James Speight, Douglas I. Exall (2002)"Refining Used Lubricating Oils"April 7, 2014 by CRC Press.

[3] Al-Omari, S.B.(2008) "Used Engine Lubrication Oil as a Renewable Supplementary Fuel for Furnaces 1" Energy Conversion and Management, Vol. 49, Issue. 2, pp. 3648-3653.

[4] MartinsJ.P. ,(1997) "The extraction-flocculation re-refining lubricating oilProcesses using ternary organic solvents," Ind. Chem. Res., 36, pp.3854-3858.

[5] Levenspiel, O.,(1999) "Chemical reaction engineering" John Wiley and Sons Inc.3ed**.**

[6] Speight, J.G.(1999) "The Chemistry and Technology of Petroleum,",3rd ed. Marcel Dekker, New York.

[7] Gary, J. H., and Handwerk, G. H. (2001) Petroleum Refining Technology and Economics. 4th ed. Marcel Dekker, New York.

[8] A. Alkilani.Haitham M. S. Taher A. AL-Sahhaf (2010) "fundamental of petroleum refining".

معالجة زيوت التزييت المستعمله باستخدام عمليات تحويليه حراريه

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الخلاصة :

هذا البحث يتعلق بدراسة امكانية معالجة زيوت التزييت المستعمله والمتجمعهمن السيارات و المحركات الميكانيكيه المختلفه بعمليات تحويليه حراريه وبالتالي اعادة استخدامها مرة اخرى.

-تم استعمال نموذجين مختلفين من زيوت التزييت المستعمله في محرك السيارات احدهمها مستعمل لمسافه سير 2000 كم والاخر لمسافة سير 4000 كم.

تم معالجة كل نموذج على حده وذلك باستعمال جهاز التقطير الجوي(ASTM D-86) حيث تم فصل كل نموذج الى مقطعين احدهما(مقطع زيتي ومقطع مخلفات) وتم ذلك عند درجة حرارة اقصاها 350 م° وعند الضغط الجوي الاعتيادي.

تم الحصول على مقدار تحول (conversion) يصل الى 95 % للنموذج الزيتي المستعمل الاول ومعدل تحول (conversion) مقداره 92.5 % للنموذج الزيتي المستعمل الثاني.

تم تقطير كل سائل زيتي للنموذجين على حدة مرة اخرى بواسطة جهاز التقطير الجوي (ASTM D-86) الى مقاطع بتروليه خفيفه ثلاث (كازولين, كيروسين , كاز اويل) للنموذجينعند الضغط الجوي الاعتيادي ,وذلك اعتمادا على درجة حرارة غليانها.

تم تقطير كل مقطع خفيف من هذه المقاطع الثلاثة ولكل نموذج زيتي مستعمل وذلك لايجاد منحنى التقطير لها لكي تتم مقارنتها مع منحنى التقطير القياسي (التجاري) لهذه المقاطع الثلاثه وبالتالي المقبوليه.

تم حساب بعض المواصفات المختبريه الفيزياويه والكيمياويه الحاكمة لهذه المقاطع الثلاثه (معدل درجه الغليان, الوزن النوعي, نقطة الوميض, نقطة الانلين, نقطة الدخان. الوزن الجزيئي)وللنموذجين وذلك لمقارنتها مع المواصفات المختبريه الفيزياويه والكيمياويه القياسيه (التجاريه) ولغرض دراسة امكانية استعمالها مره اخرى.

تم التوصل الى ان مقطع الكازاويل هو مطابق جدا من ناحية المواصفات المختبريه الفيزياويه والكيمياويه ومنحنى التقطير الى النموذجين من الزيوت المستعمله والمقطرة اضافة الى نسبته العالية مقارنة بمقطع الكازولين والكيروسين.
نسبة الكاز اويل (زيت الغاز) الناتج من النموذج الاول 50% والكازولين 15% والكيروسين 30%.

في حين كانت نسبة الكاز اويل (زيت الغاز) الناتج من النموذج الثاني 43% والكازولين 15% والكيروسين 35%.

امكانية استعمال المقاطع البترولية الثلاثة الخفيفة (الكازولين, الكيروسين, الكازاويل) والناتجة من نموذجي زيوت التزيت المستعملة , لتسير السيارات(الكازولين) والاستخدامات المنزلية (كيروسين) ووقود الديزل (الكازاويل) وذلك لتطابق المواصفات المختبرية الفيزياوية والكيمياوية لهذه المقاطع الثلاثه مع المواصفات القياسيه (التجاريه).