Determination of Some Physical and Chemical Properties for Different Samples of Petroleum Lubricants

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Abstract

Some physical and chemical properties for the different samples of lubricants oil for sewing machines, lubricants oil for car's engine before and after burn process such as, density (d), Specific gravity (Sp. gr.), standard density (API), dynamic viscosity (η), Kinematics viscosity (ν), Fludity (Φ), Refractive index (R.I), the percentage of ash (%Ash), acidity and basicity for the different samples of petroleum lubrications were determined.

The heat of combustion (gross calorific value) (Q), heat of Latent (L) and the percentage of hydrogen (%H) for the same samples were calculated also.

الخلاصة

تضمنت الدراسة تحديد بعض الصفات الفيزياوية والكيميائية لعينات مختلفة من زيوت تشحيم مكائن الخياطة، وزيوت محركات السيارات قبل وبعد عملية الحرق مثل الكثافة (d)، والـوزن النـوعي (Sp. gr)، والكثافة القياسية (API)،واللزوجة الديناميكية (η)،واللزوجة الحركيـة (ν)، و الـسيولة(Φ)، ومعامـل الانكسار(R.I)، والنسبة المئوية للرماد (%Ash)، والحامضية والقاعدية لعينات مختلفة من زيوت المـشتقات البترولية .

كذلك، تم حساب حرارة الاحتراق (القيمة الحرارية العليا) (Q)والحـرارة الكامنـة (L)، والنـسبة المئوية للهيدروجين(%H) لنفس العينات.

Introduction

Oil used in an engine must serve as: 1) a lubricant to reduce friction, corrosion and wear, 2) a coolant, 3) a vehicle for removing impurities [1] , 4) reducing operating temperatures under full load,

The properties of lubricate [4] are different by modifying the structure of it as increasing the length of chain, adding side chain and adding cyclic groups, all that will increase the viscosity and decrease the viscosity index.

5) increasing component life and 6) reduce energy consumption[2].

Most lubrication oils [3] are a mixture consisting predominantly of hydrocarbons and compounds containing sulphur, nitrogen, oxygen and trace metals as minor constituents.

The lubrication oils [1] in modern engines must operate over an extreme temperature range and should

be non-toxic and non-explosive, all that will prove by employing additives such as [5, 6] antioxidant (amines, phenols), corrosion inhibitor, detergent and dispersant (Ca, Ba compounds, soaps), alkalinity (Ca, Ba hydroxides), antibacterial (biocides), Oiliness or wetting agents (fatty oils, chlorinated wax), Extreme pressure agents (organic compounds of Cl, S, P (hydraulic, gear oil)), pour point depressant (organic polymers), antifoam (silicanes), viscosity index improvers (organic polymers) and emulsifying agent (polar compounds).

The lubrication oil used as a cheap source of fuel to the urban poor enterprises and households by employing drip method[7].

The characteristics of lubrication oil depended on its crude oil. It is different from oil field to other oil field, that indicated to different in a constituation of it, that was explained in the table(A):[8,9]

Table (A): The element Composition in (Wt %) range for crude oil

The elements	Element composition Wt % range
Carbon	83.9 - 86.8
Hydrogen	11 - 14
Sulfur	0.06 - 8
Nitrogen	0.02 - 1.7
Oxygen	0.08 -1.82
Metals	0.0 - 0.14

The many researchers studied how to increase the ratio of hydrogen to carbon in petroleum to increase the product energy, according to the following equation [10-12].

$$C_nH_m + 9H_2 \xrightarrow{(543-723)^oK} 2C_{\frac{n}{5}}H_{\left(\frac{m}{2}+a\right)}$$

a=constant depended on the type of hydrocarbon product.

Mrena and Coworkers[13] found the some physical and chemical properties of lubrication oils like net calorific value, gross calorific value Sp.gr at 30 and 60^{o}C , viscosity at 30 and 60^{o}C ……etc.

Hamdon[14] produced the activated carbon from spent Lubricating oil by employing oxidation condensation process.

Hendy and Coworkers[15] studied the chemical changes which occurred in oil emulsion by the action of eight different species of bacteria isolated, that changed the standard engineering performance for oil emulsion and increased the rust formation and corrosion of steel samples.

Experimental Part

A- ***Instruments*:** The employed instruments are:-

1) Digital balance (Sartorius, Bp- 2015-Germany).
2) Water bath, (W 350-Germany).
3) Refrectrometr, (Atago 1T-Japan).
4) Furnace, (mke- Pe 100 – Canada).

B-*Materials and Procedure:*

Six samples were studied, according to the table (B):

No.	Sample	Countries	Colour
1	Lubricants oil for sewing machines	Iran	Pale- yellow
2	Lubricants oil for sewing machines	Iraq	Light- yellow
3	Lubricants oil for sewing machines	Iraq	Brown –yellow
4	Lubricants oil for car's engine before burn	Germany	Yellow-brown
5	Lubricants oil for car's engine before burn	Iraq	Green- brown
6	Lubricants oil for car's engine after burn	Iraq	Black-brown

*The mechanical properties were determined such as, density (d), specific gravity (Sp. gr.), standard density (API), dynamic viscosity (η), kinematics viscosity (ν) and fluidity (Φ).

The densities(d) (at 15 ^{o}C and 38 ^{o}C) were measured by pyknometer method according to the equation(1) [16]:

$$d = \frac{m_{sample}}{m_{D.W}} \times \rho_{D.W} \quad (\text{at } 15\ ^{\circ}C \text{ and } 38\ ^{\circ}C) \quad \text{.....(1)}$$

$\rho_{D.W}$ = the densities of D.W.

The specific gravity was found by equation (2)[13]:

$$Sp.gr. = \frac{d_{sample}}{\rho_{D.W}} \quad at \quad (15)^{\circ}C \quad \text{.....(2)}$$

The degree (API) gravity was determined at 15 ^{o}C by American Petroleum Institute of the following equation [17,18]:

$$\text{API Scale} = \frac{141.5}{\text{Sp. gr.}(15\ ^{\circ}C)} - 131.5 \quad \text{.....(3)}$$

Dynamic (absolute) viscosity (η)[16] is determined by the time of flow of studied samples and D. W at 38 ^{o}C.

$$\frac{\eta_{sample}}{\eta_{D.W}} = \frac{d_{sample}\ x\ t_{sample}}{\rho_{D.W}\ x\ t_{D.W}} \quad \text{.....(4)}$$

The kinematics viscosity (ν)[19]is calculated by dividing the dynamic viscosity (η) to the density (d) at 38 ^{o}C.

$$\nu = \frac{\eta}{d} \quad (\text{at } 38\ ^{\circ}C) \quad \text{.....(5)}$$

The fluidity (Φ) was calculated by employing equation(6)[16,19]

$$\Phi = \frac{1}{\eta} \quad (\text{at } 38\ ^{o}\text{C}) \qquad \text{.....(6)}$$

* The optical property, refractive index (R.I) was measured at 20 ^{o}C by employing Abbi refractometer, so the R.I is regarded as an indicator of light- colored liquid petroleum products [20].

*The acidity and basicity were measured by titration method [21]:

mmole of base = mmole of sample ……(7)

*The hydrogen content (%H) was calculated by following equation[.22]:

$$\%H = 26 - (15\ x\ Sp.gr.) \quad (\text{at } 15\ ^{o}\text{C}(60\ ^{o}\text{F})) \quad \text{.....(8)}$$

*The thermal property, heat of combustion (gross calorific value) (Q) and heat of Latent (L) were calculated by equations (9,10)[23]:

$$Q = 12400 - (2100 \times (Sp.gr)^2) \quad (\text{at } 15\ ^{o}\text{C}(60\ ^{o}\text{F})) \qquad \text{.....(9)}$$

$$L = \frac{1}{Sp.gr} \times (110.9 - 0.09\ t) \quad (\text{at t} = 60\ ^{o}\text{F}) \qquad \text{.....(10)}$$

*The % Ash was measured by following equation (11) [24]:

$$\%\ Ash = \frac{W_{sample\ after\ burn}\ (g)}{W_{sample\ before\ burn}\ (g)} \times 100 \qquad \text{.....(11)}$$

Results and Discussion

Table(1-A): Some mechanical properties (d, Sp.gr & API) for studied samples at ($t = 15 \pm 1\ ^{o}C$)

No. of samples	Density (g/ mL)	Specific gravity (Sp. gr)	API
1	0.88577	0.87354	30.4845
2	0.85178	0.84001	36.9503
3	0.86746	0.85548	33.9042
4	0.91877	0.90608	24.6672
5	0.98581	0.97219	14.0476
6	0.92177	0.90904	24.1587

* $\rho_{D.W}$ =1.0140 gm/mL

From the previous table, the sp. grs for all samples were approved with the standard range [25] (0.85 – 0.97) except sample (2) due to presence of a low amounts of nephthene compounds [24].

The sp.gr of sample (6) was low compared with sample(5) that

beyond to break its molecules during the burning process at 260- 400 ^{o}C in engine of car which cause the dissociation of its[26].

According to the standard range for API (>15) [23, 25, 27], that refereed to approve with the API for all samples except sample (5) due to the same reason.

Table(1-B): Some Mechanical Properties (d, η, ν, Φ) for studied samples at ($t = 38 \pm 1\,^{o}C$)

No. of samples	Density (g/ mL)	(η) Poise	(ν) cSt	(Φ) poise^{-1}
1	0.8084	0.6740	83.3745	1.4836
2	0.8482	0.3700	43.6215	2.7027
3	0.8648	0.3955	45.77326	2.5284
4	0.8728	1.2176	139.5050	0.8212
5	0.9143	2.0108	219.9278	0.4973
6	0.6390	1.4559	227.84037	0.6868

$\rho_{D.W}$ = 0.99497 gm/mL

According to the results in table (1-B), the density is decreased with the temperature, because oils are expansion with increased temperature[28].

In general, the standard range for kinematics viscosity equal (15-150 cSt)[23]. But the kinematics viscosity for samples (5) is very high, may be a cause for the amount and the nature of additives which add as anti-oxidant, anti-corrosion, anti-microbiology, equilibrium matters and emulsion matter[29, 30].

The sample 6 was had a high value of Kinematics viscosity that due to corrode the iron of engine's car during the burning processes.

The fluidity of sample (3) is more than fluidity of sample (5), that referees to a low dynamic viscosity.

Table(2): The optical properties (Colour and refractive index) for studied sample at ($t = 20\,^{o}C$)

No. of samples	Colour	R.I At 20^{o}C
1	Pale yellow	1.474405
2	Light yellow	1.472405
3	Brown-yellow	1.473405
4	Yellow- brown	1.462038
5	Green-brown	1.494540
6	Black-brown	-

According to the results in table(2), that occurred the values of R.I of samples 1,2 and 3 were very close to each other, because they are light oils which used as lubrication for sewing machine.

But the R.I for sample 4 is smaller than R.I for sample 5, in spite of they were employed in lubrication process for the car's engine, that may be a cause to the amount and the nature of additives [29, 30].

The sample 6 wasn't showed a value of R.I that beyond to corrode the iron of engine's car during the burning processes with the time.

Table (3): The values of basicity and acidity for the studied samples at ($t = 30\ ^oC$).

No. of samples	Basicity M	Acidity M
1	-	0.0100
2	-	0.0020
3	-	0.0016
4	-	0.006
5	-	0.002
6	-	0.094

According to results in table (3), the values of acidity were most lower to prevent the corrosion process in sewing machine and car engine.

The acidity for sample 6 was highest than acidity for other samples, that beyond to exist some oxygen compounds as result to react the lubricant with atmosphere oxygen during burned it in engine car, to give peroxide compound[24, 31], the increase in acidity will cause the corrosion in engine's car therefore, the spent lubricating oils will replace[32, 33].

Table(4): The values of percentage for %Ash of studied samples.

No. of samples	%Ash
1	0.860
2	0.280
3	0.592
4	30.120
5	25.020
6	26.080

From table(4) the results referred that %Ash are greater than the standard range (< 0.1)[22], due to presence of higher amount of inorganic metal like (Ni, Zn ….etc.) [24] during separation and purification processes in refineries.

Table(5): The values of thermal properties (L, Q and %H) at ($t = 15\,^{o}C,\ 60\,^{o}F$)

No. of samples	L Btu. Pound^{-1}	Q Kcal.Kg^{-1}	%H
1	121.554	10797	12.8960
2	126.622	10876	13.3998
3	124.234	10863	13.1670
4	116.995	10674	12.4088
5	134.591	10415	11.4171
6	116.596	10664	12.3644

Btu[34] :Britain temperature unit = 778 ft. Ib.

According to the results in table (5), the %H in all samples were within the standard range[2] (11.8-13.3) except sample (5) due to additives.

The heats of combustion for all samples were within standard range[23] (10504- 10882) Kcal. Kg^{-1} except sample (5), due to its high sp. gr[22]. The heats of latent for all samples were fixed with the standard range [23] (111-124) Btu. Pound^{-1} except sample (5)[22] due to the same reason.

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