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EVALUATION THE PERFORMANCE OF LOCAL AND FOREIGN LUBRICATING OILS

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ABSTRACT

*It is widely accepted that lubricating oils play important role in determining the performance and the effective life in several industrial field. This work represents an attempt to compare the efficiency of Iraqi made oils (multi grade oil) with the important oils (American and emirate oil) at room temperature and 80 °C. The samples used in this work were made of Al_alloy (A356). Several metallurgical, chemical and mechanical tests were conducted such as, X-ray diffraction (XRD) ,Chemical composition analysis (EDS), ,corrosion, hardness and wear tests. The results showed that hardness of (A356) was 84.8HV.Theresultsof corrosion test which carried out by tafelextrapolation technique in 3.5% NaCl solution showed that the corrosion rate (mpy) at RT. was ($4.522 * 10^{-5}$).The results of dry wear test at RT, indicated that the weight loss was ($70*10^{-3}$ gm) in the steady state region, While wear test results in different oils at RT. showed that the weight loss of Iraqi oil was ($6*10^{-3}$ gm) in steady state region but in emirate and USA oil, it was ($3*10^{-3}$ gm and 2.7*10^-3 gm) respectively, at 80 °Cthe weight loss of Iraqi oil in the steady state region was $4.5*10^{-3}$gmcompared with the weight loss in Emirate and USA oils ($2.5*10^{-3}$gm and $2*10^{-3}$gm)respectively. Finally, the results showed that properties of oil special viscosity plays a vital role to characterize the behavior of wear.*

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1. GENERAL INTRODUCTION

Lubricant is defined as a substance introduced between two surfaces in relative motion to prevent friction, improve efficiency and reduce wear. They can be in the form of gas, liquid or solid. The lubricant prevents the direct contact of rubbing surfaces and thus reduces wear. It keeps the surface of metals clean and prevents failure due to seizure. Lubricants can also act as coolants by removing heat effects and prevent rusting and deposition of solids on close fitting parts. One of the single largest applications for lubricants, in the form of motor oil, is to protect the internal combustion engines in motor vehicles and powered equipment [1]. Lubricants were at one time almost exclusively animal or vegetable oils or fat, but modern requirements made petroleum the main source of supply. However, fatty oils still have their uses although generally in ancillary role. The main function of a lubricant is to reduce the friction between the moving surface and so facilitate motion. Its second most important function is to remove heat generated in the equipment being lubricated, such as piston engine, enclosed gears and machine tools. It has also to remove away debris from the contact area [2].

The engine block alone accounts for 30-40% of the total weight of the average vehicle. Thus it played a key role in all weight-reduction considerations and has better thermal sensitivity than the traditional cast iron. Aluminum casting alloys as a substitute for the traditional cast iron means a reduction in engine block weight of between 40 and 55%, even if the lower strength of aluminum compared to grey cast iron is consideredfor the above mentioned reasons, materials were chosen from Al-alloy (A356) [3].

Additives to the oil serve many functions such as providing different surface chemistry for the tribological surfaces, load capacity of the fluid, viscosity temperature, and viscosity-pressure dependence [4]. Through a chemical or physical process these additives serve to create a surface layer which protects surfaces, from wear and degradation, and/or reduces the friction coefficient. Wear reduction additives within the lubricant create a surface layer to reduce wear when the oil film can no longer separate these surfaces. There are additives which combat the buildup of varnish, deposits, and sludge. Other additives help prevent rust, corrosion, and various chemical attacks. Friction reduction additives react with engine surfaces to lower friction [5].

2. EXPERIMENTAL WORK

2.1. Test materials

Al-alloy (A356) was received as a bar. Chemical composition shows in Table (1).

Table (1) Chemical Composition of A356 alloy

Specimen	Si%	Cu%	Mg%	Zn%	Mn%	Ti%	Fe%	Al
A356	7	0.2	0.35	0.1	0.1	0.2	0.2	Bal

2.2. Specimen preparation and characterization

For metallographic characterization ,samples were wet ground through successive grades of silicon carbide abrasive papers from p120 to p1200 followed by diamond finishing to 0.1μm The chemical composition of alloy casting was determined using (XRF) spectrometer type(DS-200-American).Phase composition was investigated by X-ray diffraction (XRD),using a (SHIMADZU lab XRD -600,Japan).

2.3. Electrochemical test

Electrochemical experiments were performed in three electrode cell containing The counter electrode was Pt electrode and the reference electrode was SCE and working electrode (specimen) according to the American society for testing and materials (ASTM). The potentiodynamic polarization curves were plotted and both corrosion current (Icorr.) and corrosionpotential (Ecorr.) were estimated by Tafel plots using anodic and cathodic branches. The test was conducted by stepping the potential using a scanning rate 0.4 mV/s from initial potential of 250 mV below the open circuit potential and the scan continued up to 250 mV above the open circuit potential. The test solution was aerated 3.5 NaCl solution at RT. (25˚C) and PH 6.5.

2.4. Hardness Test

Micro hardness test was used to measure hardness values by Micro hardness Vickers (HV) device type (digital micro Vickers hardness tester TH717,China),using load of (200 g for 15 sec) with a square-base diamond pyramid, the hardness was recorded as an average of five hardness readings for each sample. It is necessary to determine the hardness over small positions on the surface.

2.5. Wear Test

The dimensions of samples for wear test , were (14x5) mm as shown in Figure (1) . This test was conducted at room temperature and at 80˚C using three different kind of oils (Iraqi multi grade, Emirate and American oils). The test were achieved by using pin-on-disc test at (150rpm) and constant radius (6mm) and (5N) load . The ball of the pin was (4mm) in radius made from carbide steel, the specimen was weighted before test, then after a period of time (1,2,3,4,5,…….16)hours, the specimens are reweighted using an electric balance with accuracy (0.0001) .Figure (2) show pin-on-disc wear test.

Figure (1) Wear Specimens.

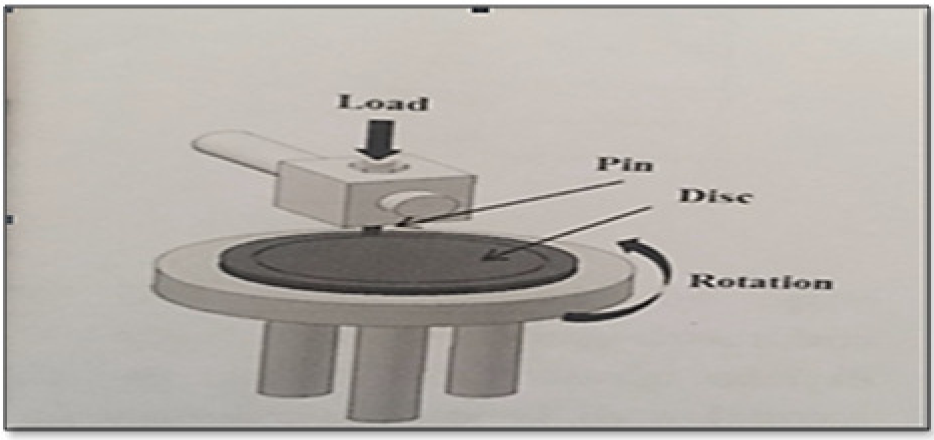

Figure (2) Pin-on-disc wear test

2.5. Properties of different oil

The properties of different oils, Iraqi(multi grade) oil, Emirate (UAE) oiland American (USA) oil was tested at room temperature and at 80˚C by using (Cone- Plate Viscometer)Type(Brocok-Field,DV-111ULTRA) as shown in Figure (3) while the flash point was tested by using SXD-3536-COC-Flash point apparatus type (Shanghai shenxian instrument co-ltd). These properties were shownin Table (2) ,Table(3) and Table(4) respectively.

Figure (3) Cone- Plate Viscometer.

Table (2) Properties of Iraqi oil (multi grade)

Type/Iraqi	25˚C	80˚C	Flash point	Fire point	rpm
Viscosity	67.59 cp	26.47 cp	224	244	8
Shear rate	30.4 1/sec	30.4 1/sec			
Shear stress	21.15 d/cm2	8.14 d/cm2			

Table (3) Properties of UAE oil

Type/UAE	25˚C	80˚C	Flash point	Fire point	rpm
Viscosity	54.96 cp	22.93 cp	229	231	8
Shear rate	30.4 1/sec	30.4 1/sec			
Shear stress	16.71 d/cm2	7.16 d/cm2			

Table (4) Properties of USA oil.

Type/USA	25˚C	80˚C	Flash point	Fire point	rpm
Viscosity	69.79 cp	8.17 cp	212	215	8
Shear rate	30.4 1/sec	30.4 1/sec			
Shear stress	2.06 d/cm2	2.46 d/cm2			

3. RESULT AND DISCUSSION

3.1. Chimical analysis

The chemical composition for A356 alloy, were analyzed by using (X-ray florescent test). The composition analysis confirm that the main alloying elements are presented within the specified limits. As shown in Table (5) with their chemical composition analysis which shown in Figures (4).

Table (5) Chemical Composition of the alloy

Specimen	Si%	Cu%	Mg%	Zn%	Mn%	Ti%	Fe%	Ni%	Al
A356	6	0.3	0.25	0.13	0.08	0.3	0.28	0.023	Bal.

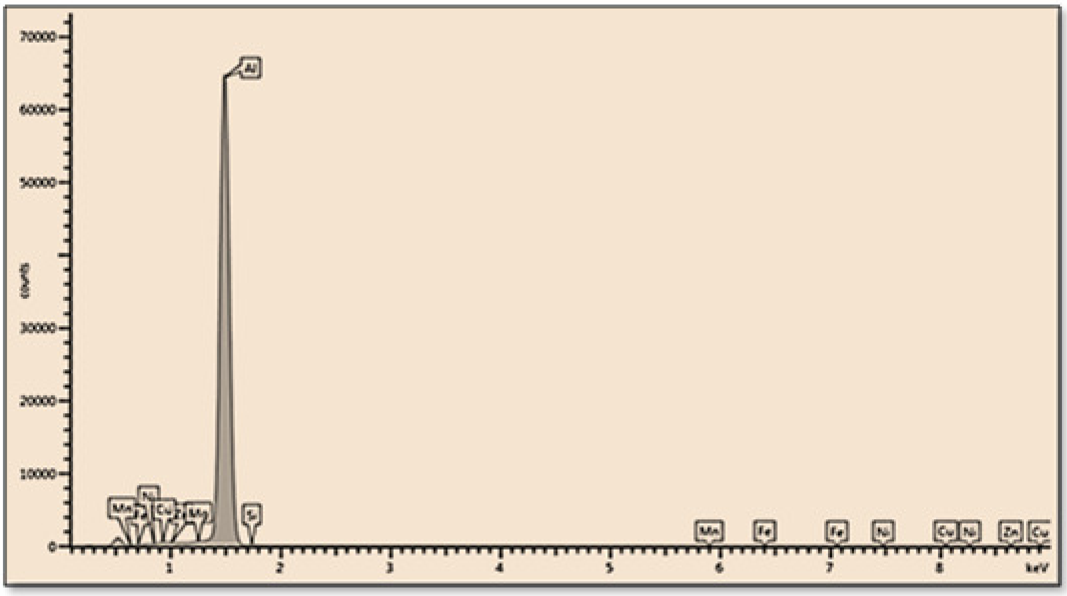

Figure (4): Chemical Analysis for (A356) Cast Alloy.

3.3. X-ray Diffraction analysis

The technique of XRD is important to identify the phases of crystalline structure. Figure (5) showed the XRD pattern of A356 alloy, it can be observed the presence of α-Al phase and Si in addition to Fe compounds.

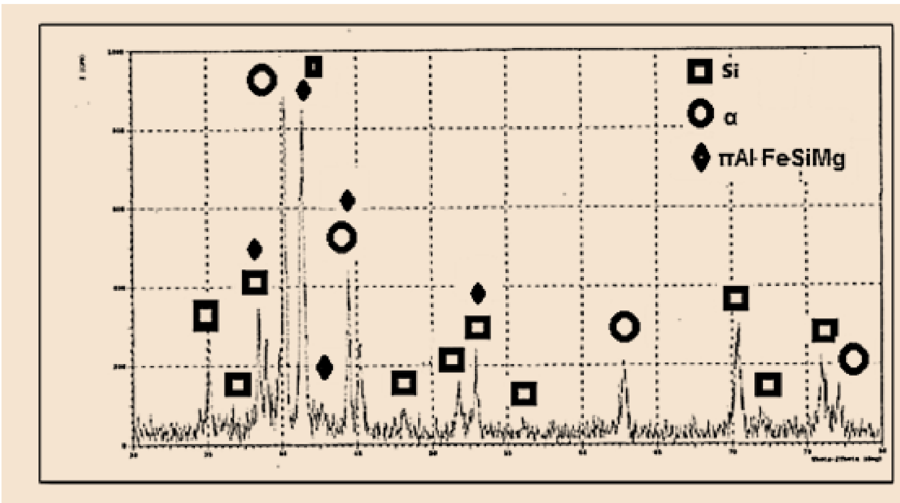

Figure (5) XRD pattern of A356 alloy

3.4. Electrochemical test

The corrosion rate of A356 alloy in 3.5 w% NaCl at room temperature was ($4.5*10^{-5}$) mpy as shown in Table (6). Figure (6) showed the polarization curve for this alloy in 3.5 w% NaCl at room temperature.

Table (6) Corrosion Parameters (I corr., E corr., and Corrosion rate (mpy)) for A356 alloy in 3.5 w% NaCl at RT.

Specimen	Icorr.(µA/)/Cm²	E corr. (mV)	Corrosion rate (mpy)
A356	6.39	-859.0	4.522 *10⁻5

Formation of a protective passive film from Al_2O_3, TiO_2 contribute in protected A356 alloy from corrosion [6].

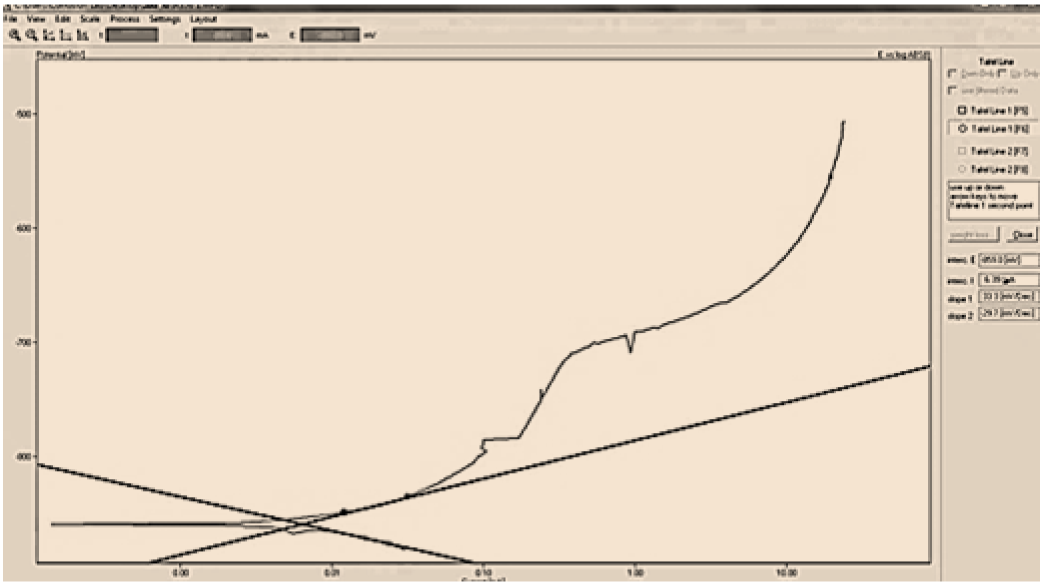

Figure (6): Polarization curve in 3.5 wt.% NaCl solution for A356 Alloy.

3.5. Hardness test

The hardness result of this alloy was shown in Table(7), presence of elements (Fe,Ti, Cu,..) all these elements involved in increasing strength of this alloy by S.S. hardening, dispersion hardening [7].

Table (7): Hardness of the alloy.

Alloy	(HV. kg/mm2)
A356	84.8

3.6. Wear test

3.6.1 Dry Wear Test.

As it known, wear test is one of most power full tool to determine the efficiency of the lubricating in dry wear at room temperature, this alloy shows traditional behavior, the weight loss was (70*10^-3) in the steady state, this behavior was expected, in the first stage “increasing in weight loss “because the contact area “asperities” small, so the stress will be higher, with time, deformation take place and the contact area will increase, which causing a decrease in the stress and weight loss were decrease also, until steady state [9] as shown in Figure (7)

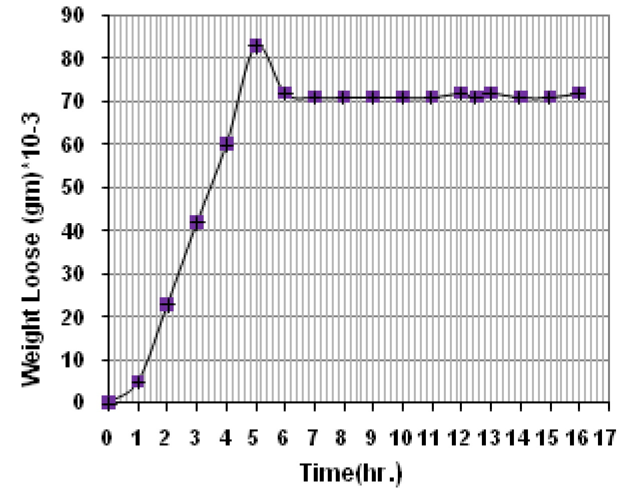

Figure (7) Weight loose vs time for A356 under (5N) load in dry condition at RT.

3.6.2. Uses Different Oils

3.6.2.1. At room temperature

Different oils use in this work (local oil and commercial) the purpose of this work is to evaluate the performance of (local oil Baghdad multi grade oil) make in Al_dora refinery /Iraq.

_Any lubricant oil showed have a specific requirement, they are able to keep surface separate under all loads, temp and speeds, thus minimizing friction and wear. Also act as cooling fluid, remain adequately stable protect surface from the attack of aggressive product form during operation, show cleaning capability and dirt holding capacity. This means oil properties must meet these requirements. The main properties of any oil used as lubricant will be, viscosity, fire point, flash point, Table(8) shows the main properties of local and commercial oils which used in this work at room temperature.

Table (8) The main properties of local and commercial oils which used in this work at room temperature.

Oil	Viscosity cp	Flash point	Fire point	Shear stress D/cm3	Shear rate 1/sec	rpm
Baghdad multi grade	67.59	224	244	21.15	30.1	8
UAE	54.96	229	231	16.71	30.4	8
USA	69.79	221	215	2.061	30.4	8

Figure. (8)shows the weight loss behavior of different oils at room temperature .These results were calculated in the same condition (load, speed, time) at room temperature, it is clear from the figure that the weight loss for Iraqi oil was (6*10^-3gm) in steady state region, while for Emirate and American oil was (3*10^-3, 2.7*10^-3)gm respectively in steady state region .

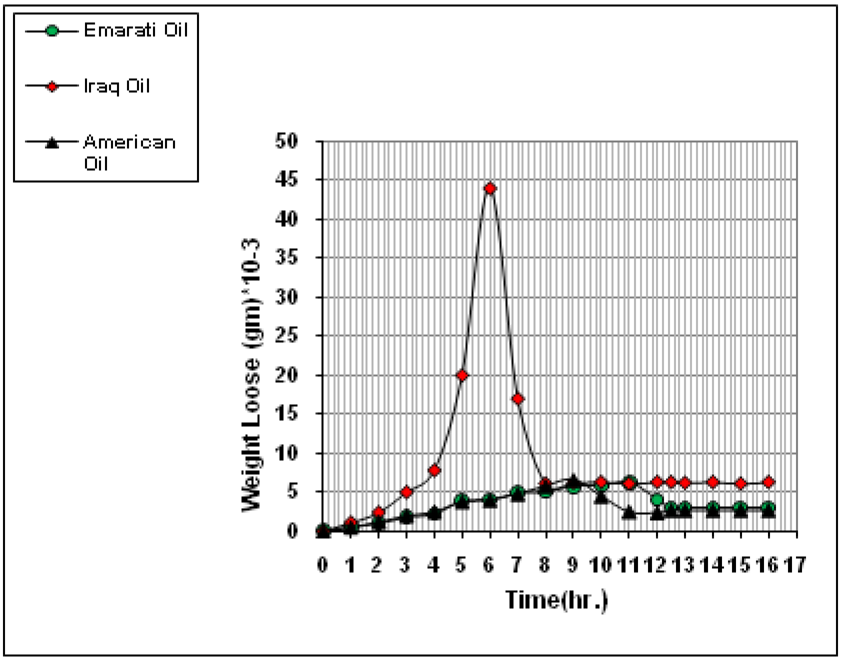

Figure (8) Weight loss Vs Time for A356 alloy in different oil at RT

Obviously, weight loss of this alloy immersion in USA oil is the minimum compare with Iraqi and even Emirate oil. This can be attributed to the viscosity values of these oils, as shown in Table.(8).USA oil have higher viscosity compare with others at room temp, so we can expected a better behavior (less weight loss). The properties of any lubricant determined or adopted as well as with chemical composition and additives. chemical composition has a close relationship with source oil (mineral oil or synthetic oil) [10].

Also additives have agreat important effects on properties, behavior of oil, additive are a combination of several chemical components that blended with base oil to enhance stability and to add specific performance feature. also additives contain different elements that will extend the life of the lubricants and a result the life of engine [11].

Unfortunately, we cannot know the chemical composition or additives of any kind of oils. It seems to be a manufacturing secret.

3.6.2.2. At higher temperature (80˚C)

It is very important to know the behavior and properties of the lubricant oil when the temperature was raised [9].Table. (9) showed these changed in oil properties when temperature raised to 80˚C.

Table (9) properties of different oils at80˚C

oil	Viscosity cp 80˚c	Shear stress D/cm3	Shear rate 1/sec	rpm
Iraqi	28.47	30.1	8.14	8
UAE	22.95	30.1	7.16	
USA	8.17	30.1	2.46	

According to Table (9), viscosity of all lubricant oils changed and became lower . American oil (had minimum value (8.17 cp) compare with Iraqi and UAE lubricant oil, as in

Figure.(9)it is obvious that the American oil gives the lowest weight loss(2*10^-3) compare with Iraqi and UAE oil(4.5*10^-3 gm) and (2.5*10^-3,) gm respectively at steady state region.

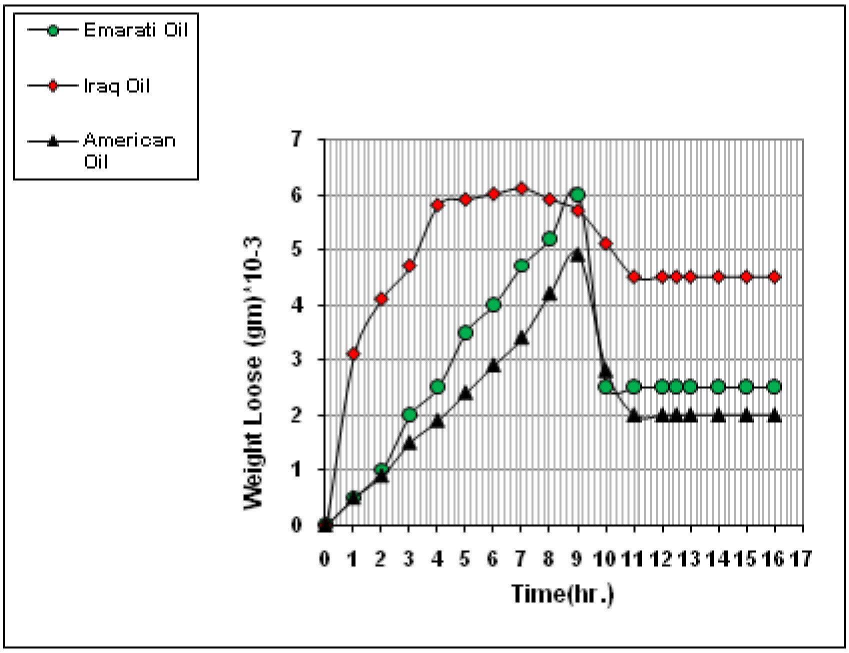

Figure (9) Weight loss Vs Time for A356 alloy in different oil at 80˚C

From this, we conclude that American oil continued to maintain as the best result, where the weight lost is the minimum, the efficiency of American oil with respect to Iraqi oil is equal to 50% at room temp while in 80˚C is equal to 55%, also efficiency of emirate oil with respect to Iraqi oil is equal to 45% at room temp while at 80˚C is equal to 44%as shown in Table. (10)

Table (10) Weight Loss at Steady State for Different Oil and Efficiency

oil	Weightloss x 10^{-3} gm (25 C°)	Weightloss x 10^{-3} gm (80C°)	Efficiency % (25 C°)	Efficiency % (80 C°)
Iraqi	6	4.5		
UAE	3	2.5	45	44
USA	2.7	2	50	55

4. CONCLUSION

- At room temperature weight loss of A356 alloy at steady state is minimum in American oil, then emirate oil then Iraqi oil
- When temperature rise (80˚c) weight loss of A356 alloy at steady state also American oil, then emirate oil then Iraqi oil
- It seems that the Iraqi oil has less or no effective additives.

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