Global Scientific JOURNALS

GSJ: Volume 8, Issue 4, April 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

Case study of the effect of Hydrogenated Styrene-diene on the viscosity of Group-1 base oil and Soybean Oil Vs Group-2 base oil

*Zain Khalid

*University Of Karachi

Abstract:

As the lubricants play a vital role in the machinery by reducing friction between the parts of the machine, cool it because friction cause the heat and heat cause to reduce the material strength that lead to cause wear and tear in the parts of machine. Generally, lubricants applications are industrial, automotive, transformer etc. that use different grades of different viscosities. So, it would be difficult to produce the base oil of all such viscosities from the refineries. So a refinery produces a range of base oil with specific viscosity that the blending companies use to manufacture the lubricants to meet the industrial demand. one of the most difficult problem is to handle the lubricants of vide range of viscosity. so, in this article Hydrogenated Styrene Diene is investigated as the viscosity modifier by blending it with 400 HVI base oil and also with Soybean oil because Soybean oil can act as environment friendly. Results shows that Hydrogenated Styrene Diene increased the viscosity of base oil and soybean oil at all temperature but it has greater effect with the base oil rather than soybean.

Introduction:

Generally, the friction between the moving parts of the machine produce heat that can cause wear and tear in the parts and ultimately lead to reduce the life of the machine. So in general this friction is being reduce by using the lubricants. Lubricants enable equipment to work for long with mild wear, reducing risk of damage and breakdowns that are most likely to occur. They are organic compounds used to reduce the friction when the surface area of the parts interacts with each other, absorb heat produce during its movement, clean the parts of the engine, and ultimately reduce the rate of wear and tear.[1] Lubricants are generally based on the mineral oil including: Group-1, Group-2 and Group-3 (semi mineral based oil), some of the research papers also show results obtained from the vegetable oil with specific properties nearly similar to the mineral oil lubricants. As the base oil stock obtained from the crude oil is not an environmentally friendly. Many researchers have studied on the vegetable oil and the results shows that these vegetable oil can be used as lubricants in industry. Such as the wear properties of Soybean oil has been discovered in four-ball tester with additive zinc dithiophosphate (ZDDP) by setting a different speed, temperature and at a fixed load of 25 lbs. [2]

When the lubricants are used for the purpose to reduce the friction it causes or generates some other problems in its built-in properties. As the lubricants have its properties of higher viscosity than the other liquids and the viscosity is the malfunction of temperature[3]. When the lubricants are used in the machine that generates heat, it causes the lubricant to thin very quickly and loss it shears stability. So some of the additives are required to maintain this property; like to thick at very low temperature and become very thin at higher temperature. This paper generally discusses the effect of hydrogenated styrene-diene on the viscosity and viscosity index of the Group-1 base oil and vegetable oil with different proportion of Hydrogenated styrene-diene in the base oil and vegetable oil and then compare with the 500-Gs Group-2 base oil. This paper also discusses that is there any possibility to replace the vegetable oil with base oil in term of its viscosity maintenance at lower and higher temperature.

Material:

Base oil under investigation is taken from National Refinery Limited, Pakistan. 400 HVI Group-1 base oilcontaininglessthan90masspercent saturates and / or greater than 0.03 mass percent Sulphur [4] and having a viscosity index greater than or equal to 80 and less than 120 given in table-1, Soybean vegetable oil and Chemical (Hydrogenated Styrene-diene) is used. 500-Gs Group-2 base oil having a saturation level greater than 90% and Sulphur content less than 0.03% is used for the comparison. Further specification is given in table-1.

API BASE OIL CATEGORIES

	Base Oil Category	Sulfur (%)		Saturates (%)	Viscosity Index
Mineral	**Group I (solvent refined)**	>0.03	and/or	<90	80 to 120
Mineral	**Group II (hydrotreated)**	<0.03	and	>90	80 to 120
Mineral	**Group III (hydrocracked)**	<0.03	and	>90	>120

Table-1

After selecting the base oil stock for investigation. Now, the blend of 400 HVIGroup-1 base oil and Soybean oil with hydrogenated styrene-diene in different proportion shown in table-2.

Sample number	**Mineral Base oil and vegetable oil**	**Hydrogenated styrene-diene (Additive) by percentage**	**Sample oil by volume**	**Hydrogenated styrene-diene (Additive) by volume**	**Total sample by volume**
1.	400 HVI	4%	192 ml	8 ml	200 ml
2.	400 HVI	8%	184 ml	16 ml	200 ml
3.	Soybean Oil	4%	192 ml	8 ml	200 ml
4.	Soybean Oil	8%	184 ml	16 ml	200 ml

Table-2

Methodology:

Some of international standard equipment have used in testing the sample. Viscosity bath and calibrated viscometerhave been used for viscosity. ASTM D-445 for viscosity and ASTM D-2270 for viscosity index have used to insure the accurate results. Here the pour point is measured just to insure the influence of the Hydrogenated Styrene-diene on the pour point of the samples.

1. Equipment:

A. Calibrated Viscometer and Viscometer Bath:

The ASTM Ubbelohde and BS/U calibrated viscometers were used to estimate the kinematic viscosity of the oils.

2. Experimental Procedure:

A. Viscosity test:

Sample was poured into the first tube of the viscometer. The filled viscometer was then placed in the viscometer bath at a temperature of 40 ^{o}C. It was then left for about 15 minutes so that the sample would attain the temperature of 40 ^{o}C. A pipette filler/sucker was placed through the second tube, and then the third tube was closed while the liquid was sucked up into the ball part of the tube. The time it took for the liquid to move from the mark above the ball to the one below was recorded. The procedure was then repeated at 60^{o}C, 80^{o}Cand 100^{o}C.

The kinematic viscosities were calculated using;

V= C*t

Where:

V= Viscosity of the sample

C= Viscometer constant

t = Time taken

B. Viscosity Index:

ASTM D-2270 has been followed to measure the viscosity index of the different samples. Viscosity index is the dimensionless number that indicate and show the effect of change of viscosity of the liquid on temperature. Relation of viscosity index with temperature is such that, greater the viscosity index (VI) smaller the change in the fluid viscosity for a given change in temperature, and vice versa. Means a fluid with low viscosity index will experience a relatively large change in its viscosity as the temperature changed [5].

The VI of the oil being considered is defined by the relationship of its 40 °C viscosity (called U) to the parameters L and H. If U is between L and H, the VI is the percentage of the way U is from L and H:

VI = 100*(L - U) / (L - H)

A completely different calculation is used for the oils where U is smaller than H, which is true for oils with VI greater than 100. For these oils, the VI is defined by a new parameter N, calculated from H and Y rather than H and L. Y is the viscosity of oil at 100°C in cSt. [6]

$$L = aY^2 + bY + c$$

$$H = dY^2 + eY + f$$

The values of a,b,c,d,e& f are given in table-6.

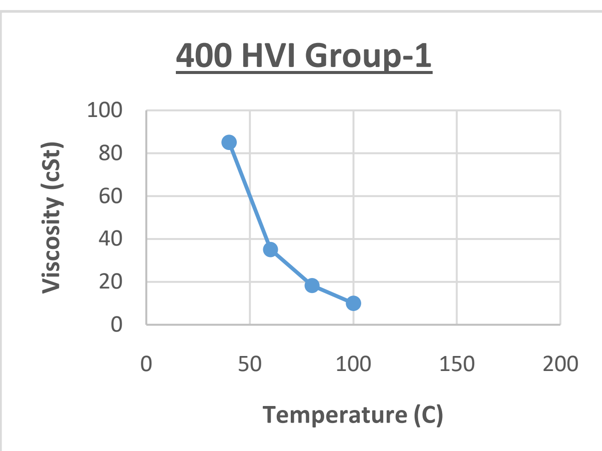
Results:

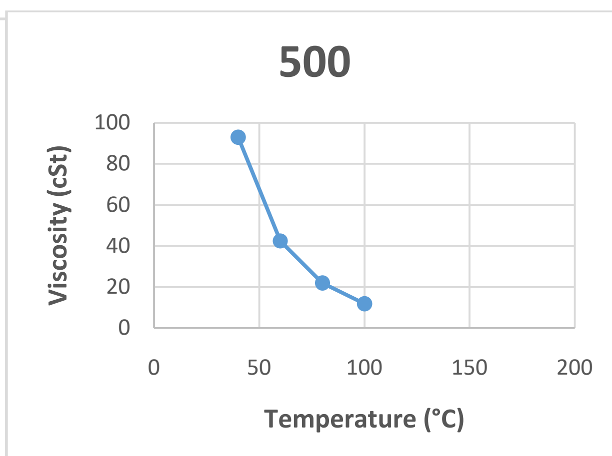
First of all, their viscosities and pour point have been found in their fresh state, viscosity index the viscosity of 400 HVI Group-1, 500-Gs Group-2 and Soybean oil at different temperatures have been noted and shown in table-3.

Results	**400 HVI**	**500**	**Soybean oil**
Viscosity at 40°C	85.08cSt	93cSt	36.33 cSt
Viscosity at 60°C	35.02cSt	42.47cSt	18.79 cSt
Viscosity at 80°C	18.22cSt	22.04cSt	12.04 cSt
Viscosity at 100°C	9.90cSt	11.89cSt	7.48 cSt
Viscosity Index	95	119	179
Density (g/cm³)	0.8899	0.8735	0.9171

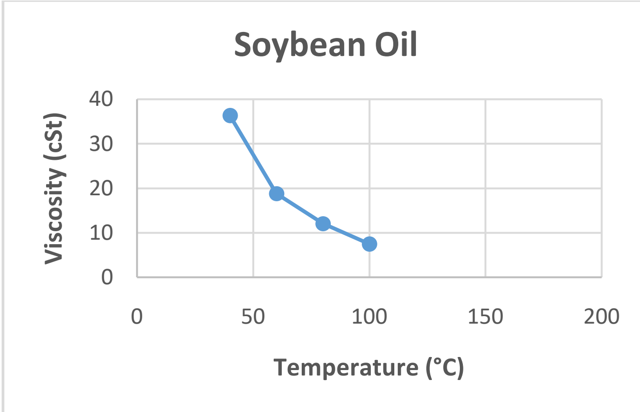
Table-3

Now, the viscosities of 400 HVI, 500 and Soybean Oil obtained at different temperatures is plotted in graph-1, graph-2 and graph-3.



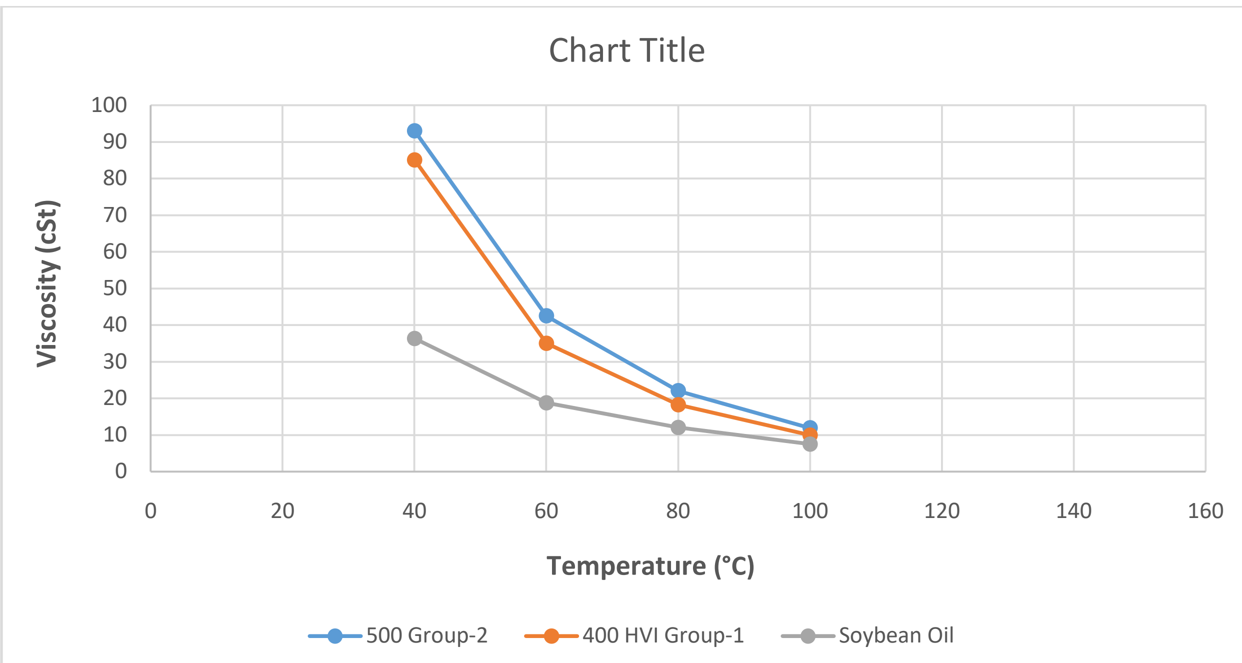


Graph-1Graph-2



Graph-3

In order to discuss their viscosities changes with respect to the temperature allthe graphs are merged that what is the viscosities changes difference in all (400 HVI Group-1 and 500 Group-2) and Soybean Oil with temperature. As shown in graph-4.



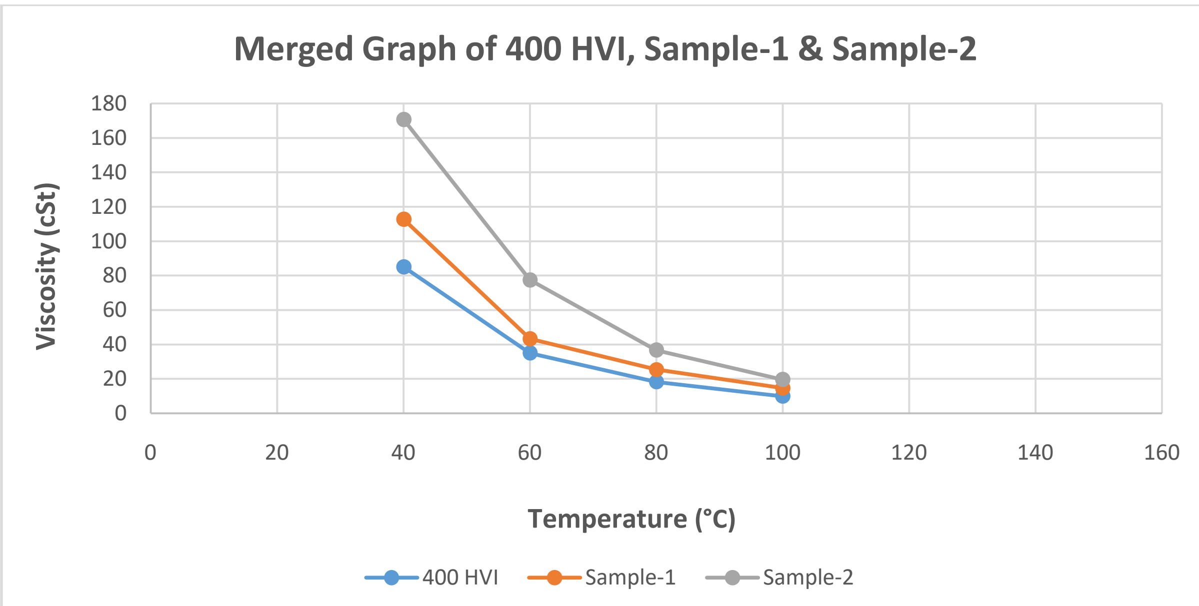
Graph-4

It can be seen that both the mineral oils have greater viscosity difference at 40°C but at 100°C both have nearly viscosities, in which the 500 Group-2 have higher value that ultimately led to high viscosity index because lesser the change in the viscosity at higher temperatures lead to higher viscosity index. On the other side, in case of Soybean Oil, it shows a very less change in viscosity between the 40°C and 100°C that's why it has a relatively higher viscosity index all over.

Now all the sample that was prepared with different proportion of the additive is testedand the following results have been obtained.like 400 HVI with 4% and 8% Hydrogenated styrene diene is shown in table-4 and its graphical analysis is shown in grahp-5, similarly Soybean oil with 4% and 8% is shown in table-5 and its graphical analysis in graph-6.

Results	**Sample-1** (400 HVI with 4% Additive)	**Sample-2** (400 HVI with 8% Additive)
Viscosity at 40°C	112.83cSt	170.81cSt
Viscosity at 60°C	43.30 cSt	77.49cSt
Viscosity at 80°C	25.36 cSt	36.71cSt
Viscosity at 100°C	14.61 cSt	19.57cSt
Viscosity Index	133	132
Density (g/cm³)	0.8929	0.8854

Table-4



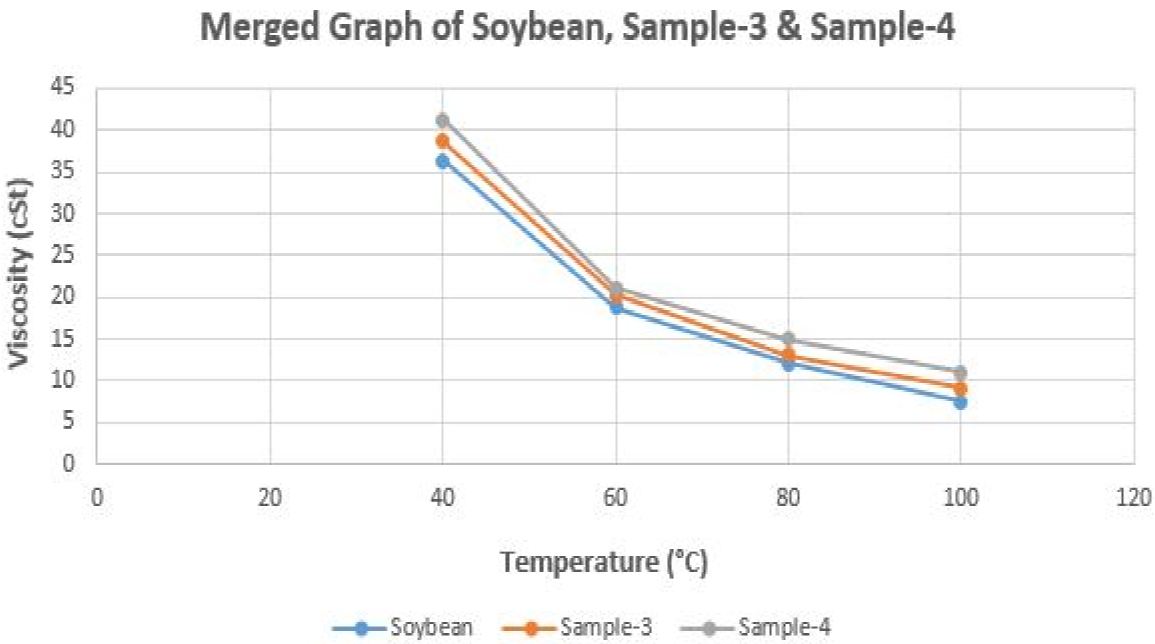
Graph-5

It can be seen in graph that the behavior of Hydrogenated Styrene diene at different proportion in base oil 400 HVI is similar with the increase in temperature as it without the additive. With the addition of 4% Hydrogenated Styrene Diene in the base oil viscosity is increased at all the temperature, such as at 40°C kinematic viscosity is increased from 85.08 cSt to 112.83 cSt and at 100°C it is increased from 9.90 cSt to 14.61 cSt. Addition of Hydrogenated Styrene Diene also increases the viscosity index of the base oil from 95 to 133 it shows that the Hydrogenated Styrene Diene resist the impact of increasing temperature on the viscosity of the base oil. It is derived that there is 40% increment in the viscosity index of the base oil by adding 4% Hydrogenated Styrene Diene. Similarly, by adding 8% kinematic viscosity at 40°C is increased from 85.08 cSt to 170.81 cSt and at 100°C kinematic viscosity is increased from 9.90 cSt to 19.57 cSt. But there is no further change in viscosity index of the base oil with the further addition of Hydrogenated Styrene Diene.

Results	**Sample-3** (Soybean with 4% Additive)	**Sample-4** (Soybean with 8% Additive)
Viscosity at 40°C	38.60 cSt	41.21 cSt
Viscosity at 60°C	20.24 cSt	21.10 cSt
Viscosity at 80°C	13.00 cSt	14.97 cSt
Viscosity at 100°C	9.11 cSt	11.00 cSt
Viscosity Index	229	273
Density (g/cm³)	0.91184	0.91176

Table-5

Now the viscosities of Soybean oil, sample-3(Soybean Oil with 4% Hydrogenated Styrene Diene) & sample-4(Soybean Oil with 8% Hydrogenated Styrene Diene) merged in graph-6 in order to check-out the behavior of additive with Soybean oil and Base Oil.



Graph-6

It hasalso seen that the behavior of soybean oil with the Hydrogenated StyreneDiene similar to the base oil with the increase of temperature. With the addition of 4% Hydrogenated StyreneDiene in soybean oil viscosity is increased at all temperature such that at 40°C viscosity is increased from 36.33 cSt to 38.60 cSt and at 100°C viscosity is increased from 7.48 cSt to 9.11 cSt. As a result, viscosity index increased from 179 to 229 because it reduces the impact of increasing temperature on the viscosity of the soybean oil in such a way that at higher temperature soybean oil doesn't lower its viscosity as much. It is devised that 27.83% increment in the viscosity index of the Soybean Oil. Similarly, by adding 8% the Hydrogenated StyreneDienein Soybean viscosity is increased at 40°C from 36.33 cSt to 41.21 cSt and at 100°C viscosity is increased from 7.48 cSt to 11.00 cSt. As a result, viscosity index is increased from 179 to 273 means that viscosity index is increased by 52.51%.

GSJ: Volume 8, Issue 4, April 2020
ISSN 2320-9186

Conclusion:

It is concluded that:

1. By adding 4% Hydrogenated Styrene Diene in 400 HVI base oil viscosity is increased about 44.50% at 40°C and 47.5% at 100°C. Similarly, by adding 8%, viscosity is increased about 100.9% at 40°C and 97.67% at100°C.
2. By adding 4% Hydrogenated Styrene Diene in Soybean oil, viscosity is increased about 6.24% at 40°C and 21.79% at 100°C. Similarly, by adding 8%, viscosity is increased about 13.44% at 40°C and 47% at 100°C.
3. It is observed that Hydrogenated Styrene Diene increased the viscosity of base oil and soybean oil at all temperature but it has greater effect with the base oil rather than soybean.

Recommendations:

It is recommended that:

1. Hydrogenated Styrene Diene can be used as the viscosity modifier because it increases the viscosity at all the temperature.

2. 4% Hydrogenated Styrene Diene in the base oil increases the viscosity at 100°C so much that the blended based oil can be used in automobile for multi-grade lubricating oil such as 20W-40. According to SAE viscosity grade for 20W-40, the viscosity range at 100°C is 12.5 cSt to 16.3 cSt& for 20W-50 it is 16.3 cSt to 21.9 cSt. Similarly, with 8% Hydrogenated Styrene Diene the blended base oil can be used for 20W-50.

3. 4% Hydrogenated Styrene Diene in Soybean oil also increases the viscosity at 100°C so that it can be used for multi-grade 5W-20. Similarly, 8% Hydrogenated Styrene Diene makes the soybean oil viscosity at 100°C suitable for 10W-30 & 5W-30.

Coefficients of Quadratic Equations

Y min	*Y* max	*a*	*b*	*c*	*d*	*e*	*f*
2.0	3.8	1.14673	1.7576	−0.109	0.84155	1.5521	−0.077
3.8	4.4	3.38095	−15.4952	33.196	0.78571	1.7929	−0.183
4.4	5.0	2.5000	−7.2143	13.812	0.82143	1.5679	0.119
5.0	6.4	0.10100	16.6350	−45.469	0.04985	9.1613	−18.557
6.4	7.0	3.35714	−23.5643	78.466	0.22619	7.7369	−16.656
7.0	7.7	0.01191	21.4750	−72.870	0.79762	−0.7321	14.610
7.7	9.0	0.41858	16.1558	−56.040	0.05794	10.5156	−28.240
9.0	12	0.88779	7.5527	−16.600	0.26665	6.7015	−10.810
12	15	0.76720	10.7972	−38.180	0.20073	8.4658	−22.490
15	18	0.97305	5.3135	−2.200	0.28889	5.9741	−4.930
18	22	0.97256	5.2500	−0.980	0.24504	7.4160	−16.730
22	28	0.91413	7.4759	−21.820	0.20323	9.1267	−34.230
28	40	0.87031	9.7157	−50.770	0.18411	10.1015	−46.750
40	55	0.84703	12.6752	−133.310	0.17029	11.4866	−80.620
55	70	0.85921	11.1009	−83.19	0.17130	11.3680	−76.940
70	Up	0.83531	14.6731	−216.246	0.16841	11.8493	−96.947

Table-6

References:

[1](Bartels et al., 2003)

[2] (Cheenkachorn, 2013)

[3](Roelands et al., 1963)

[4](*Base Oil Groups: Manufacture, Properties and Performance*, n.d.)

[5]https://www.mobilehydraulictips.com/what-is-viscosity-index/

[6] (SALCEDO, n.d.)