Effect of Additives on Lubricating Oil

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Abstract— The effects Of additive formulations namely Hexagonal Boron Nitrate (hBN) on the viscosity index of lubricating oils (base oils) namely 20W40 temperatures 30 to 90 were investigated. The base oils were blended with the additives in different proportions. The results gave a viscosity index of 96 and 98 respectively for 20W40 without additives and with additives. The results revealed that 261 additive formulations gave the highest increase in viscosity in all proportions increasing as the weight of the additive increases. Generally, all the four additive formulations used improved the viscosities of all the blends in all the proportions and at both temperatures. The blends can be classified as very high viscosity index being above 110. This means that they will undergo very little change in viscosity with temperature extremes and so can be considered to have stable viscosity.

Key words: Lubricant (Base Oil), Kinematic, Viscosity, Additives, Viscosity Index, hBN, Temperatures

I. INTRODUCTION

A lubricant (also referred to as lube) 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. A lubricant prevents the direct contact of rubbing surfaces and thus reduces wear. It keeps the surface of metals clean and also prevents failure due to seizure. Lubricants can also act as coolants by removing heat effects and also 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 [API, (2002)].

There are three major types of lubricants: Gaseous lubricants e.g. air, helium, Liquid lubricants e.g. oils, water and Solid lubricants e.g. graphite, grease, teflon, molybdenum disulphide etc. Liquid lubricant is the most commonly used lubricant because of its wide range of possible applications while gaseous and solid lubricants are recommended in special applications [Boughton, (2003)]. Based on its origin, lubricating oil can be two basic categories: mineral and synthetic. Mineral oils are refined from naturally occurring petroleum, or crude oil. Synthetic oils are manufactured polyalphaolefins which are hydrocarbon-based polyglycols or ester oils and are often “tailor made” for specific application. Of all these, mineral oils are the most commonly used because the supply of crude oil has rendered them inexpensive. Also a large body of data on their properties and use already exists. Another advantage of mineral-based lubricating oils is that they can be produced in a wide range of viscosities for diverse applications. They range from low-viscosity oils (light lube oil), which consist of hydrogen-carbon chains with molecular weights of around 200 atomic mass units (amu), to highly viscous lubricants with molecular weights as high as 1000 amu. Mineral-based oils with different viscosities can even be blended together to improve their performance in a given application. [Bienkowski, (1993)].

Viscosity is a measure of the oil’s resistance to shear. It is more commonly known as resistance to flow. If lubricating oil is considered as a series of fluid layers superimposed on each other, the viscosity of the oil is a measure of the resistance to flow between the individual layers. A high viscosity implies high resistances to flow while a low viscosity indicates a low resistance to flow. Viscosity varies inversely with temperature. It is also affected by pressure; higher pressure causes the viscosity to increase and subsequently, the load-carrying capacity of the oil also increases. This property enables the use of thin oils to lubricate heavy machinery. The viscosity of a lubricant is closely related to its ability to reduce friction. Generally, we want the thinnest oil which still forces the two moving surfaces apart. If the lubricant is too thick, it will require a lot of energy to move the surfaces (such as in honey); if it is too thin, the surfaces will rub on each other and friction will increase. (1)

Two common methods for measuring viscosity are shear and time methods. When viscosity is determined by directly measuring shear stress and shear rate, it is expressed in centipoise (cP) and is referred to as the absolute or dynamic viscosity. It is more common to use kinematic viscosity, which is the absolute viscosity divided by the density of the oil being tested. Kinematic viscosity is expressed in centistokes (cSt).

Viscosity in centistokes is conventionally given at two standard temperatures: 40^0C and 100^0C (104^0F and 212^0F). Another method used to determine oil viscosity measures the time required for an oil sample to flow through a standard orifice at a standard temperature. Viscosity is then expressed in SUS (Saybolt Universal Seconds). SUS viscosities are also conventionally given at two standard temperatures: 37 ^{0}C and 98^0C (100^0F and210^0F). (2)

Viscosity index, commonly designated VI, is an arbitrary numbering scale that indicates the changes in oil viscosity with changes in temperature. It is a lubricating oil quality indicator, an arbitrary measure for the change of kinematic viscosity with temperature. Viscosity index can be classified as follows: low VI - below 35; medium VI - 35 to 80; high VI - 80 to 110; very high VI - above 110. A high viscosity index indicates small oil viscosity changes with temperature. A low viscosity index indicates high viscosity changes with temperature. Therefore, a fluid that has a high viscosity index can be expected to undergo very little change in viscosity with temperature extremes and is considered to have a stable viscosity. A fluid with a low viscosity index can be expected to undergo a significant change in viscosity as the temperature fluctuates.(3)

Many applications require a lubricant to perform across a wide range of conditions. Automotive lubricants must reduce friction between engine components when it is started from cold (relative to engine operating temperatures) as well as when it is running (up to 200 °C).

The best oils (with the highest VI) will not very much in viscosity over such a temperature range and therefore will perform well throughout. (4)

Thus an ideal oil for most purposes is one that maintains a constant viscosity throughout temperature changes.(5)

Additives are chemical compounds added to refined base oils t impart some specific properties to the lubricating oil either by enhancing inherent properties or adding new, desired ones to the finished product. A lot of unfortified base oils are being used as engine oils in our country. These base oils have to an extent some of the properties required for lubrication. However, these by themselves are not sufficient to meet the lubrication requirement of today's modern highly rated engines. Thus, it is often desired to add various chemicals to improve the physical properties of these oils. Due to the advancement in technology, varieties of machines, instruments and appliances have been developed which have to be operated at extreme new temperature, pressure and speed thus, this demands some specific characteristics from the lubricants. Base oil alone is unable to meet the demands of these modern engines; hence additive(s) that enhances the performance of such lubricant is/are needed. Various compounds have been discovered to possess operating characteristics such as oxidation stability, viscosity index, pour point, rust inhibition etc. [Bienkowski, (1993)]. Thus this work is aimed at studying the effect of four additive formulations on the viscosities of two base oils with regards to enhancing their performance in service.

II. MATERIALS

A. *Oil Selection*

1) *Type 1*

- Oil Type: Base 20w40
- Specification:

SAE GRADE	20W-40
Kinematic Viscosity cSt @ 100°C	13.5 – 15.5
Viscosity Index, Min.	110
Flash point (COC), °C Min.	200
Pour Point, °C Max.	(-) 21
TBN mg KOH/gm	9.5 – 12.5

Table 1:

2) *Type 2*

- Oil Type: Used 20w40
- Specification: Same as above

B. *Nano Partials*

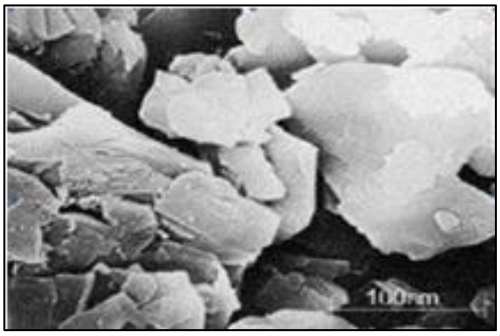

Fig. 1: SEM of Boron Nitride Nanoparticles

C. *Boron Nitride Nanoparticles*

Product : Boron Nitride Nano-powder (BN, Hexagonal, 99.8%, 80nm)
Purity : 99.8 %
APS : 80 nm
Colour : White

Density	:	2.29 g/cm³
Index	:	1.74
Coefficient	:	< 0.3
Dielectric Constant	:	3-4
Thermal Conductivity	:	40-120
Crystal Form	:	BN, Hexagonal

Table 2:

III. PREPARATION OF SAMPLE

Fig. 2: Magnetic Stirrer

A magnetic stirrer is a laboratory device that employs a rotating magnetic field to cause a stir bar immersed in a liquid to spin very quickly, thus stirring it. The rotating field may be created either by a rotating magnet or a set of stationary electromagnets, placed beneath the vessel with the liquid. WeiDai a, BassemKheireddin b, HongGao b, HongLiang

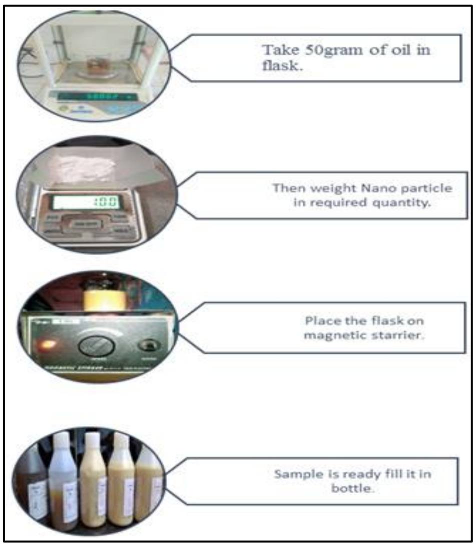

Fig. 3: Testing

A. *Viscosity Test*

The standard test method ASTM D93 used for calculate kinematic viscosity of transparent and opaque liquids. This test method specifies a procedure for the determination of the kinematic viscosity of liquid petroleum products, both transparent and opaque, by measuring the time for a volume of liquid to flow under gravity through a calibrated glass capillary viscometer. The dynamic viscosity can be obtained by multiplying the kinematic viscosity by the density of the liquid.

The time is measured for a fixed volume of liquid to flow under gravity through the capillary of a calibrated viscometer under a reproducible driving head and a closely controlled and known temperature. The kinematic viscosity is the product of the measured flow time and calibration consist of the viscometer. Two such determinations are needed from which to calculate a kinematic viscosity that is the average of two acceptable values.

The viscosity index via kinematic viscosity use for producing lubricating oil (Engine oil) for cars, buses, vans etc and 500N used for production of heavy lubricating oil for trucks, trailers, tractors, lorries etc were investigated using hBN as additives . Two masses 5g of these additives were added to base oils.

B. *Apparatus Used*

The viscosity of the Nano lubricants was measured using a Redwood viscometer.50ml of oil was used for each trial. Time required for emptying 50ml of oil was measured and viscosity was calculated using Redwood formula. Three trials were conducted for each sample. The variations of kinematic viscosities were obtaining at a temperature of 30-90ºC.

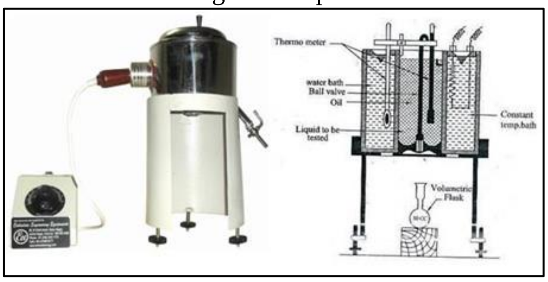

Fig. 4: Redwood Viscosity Meter

The redwood viscometer consists of vertical cylindrical oil cup with an orifice in the centre of its base. The orifice can be closed by a ball. A hook pointing upward serves as a guide mark for filling the oil. The cylindrical cup is surrounded by the water bath. The water bath maintains the temperature of the oil to be tested at constant temperature. The oil is heated by heating the water bath by means of an immersed electric heater in the water bath; the provision is made for stirring the water, to maintain the uniform temperature in the water bath and to place the thermometer to record the temperature of oil and water bath. The cylinder is 47.625 mm in diameter and 88.90 mm deep. The orifice is 1.70 mm in diameter and 12 mm in length, this viscometer is used to determine the kinematic viscosity of the oil. From the kinematic viscosity the dynamic viscosity is determined**.**

Kinematic viscosity (µ): - The ratio of absolute viscosity to density for any fluid is known as absolute kinematics viscosity. It is donated by µ and in C.G.S. system, its units are strokes and centistokes (1/100th of stoke) respectively.

$$\mu=(A \times t) - \frac{B}{t}$$

IV. OBSERVATION

1) Improve the properties of lubricating oil by adding addetives.
2) To check the effect on viscosity of oil at different temperature.
3) To compare the effect of the vicosity of both base and used oil by adding addetives.

A. *Reading*

Oil	Temperature	Time (sec)	Kinematic viscosity	Dynamic Viscosity
Base oil (20w40)	30	675.9	1.4799	1.23
	50	355.3	0.7765	0.6347
	60	238.6	0.5175	0.4196
	70	130.95	0.2743	0.2206
	80	88.53	0.1744	0.13917
	90	60.0	0.102	0.0807
Base oil (20w40) + Additives hBN	30	2252.0	4.9539	4.1271
	50	1089	2.3940	1.9571
	60	674.0	1.4800	1.2003
	70	363.7	0.7956	0.6392
	80	315.3	0.6818	0.5489
	90	265.3	0.5767	0.4562
Use oil (20w40)	30	387.22	0.8471	0.7074
	50	137.92	0.2902	0.2373
	60	80.12	0.1536	0.1246
	70	61.22	0.1050	0.0845
	80	50.0	0.073	0.05
	90	46.7	0.063	0.050
Use oil (20w40)	30	743.8	1.6327	1.3586
	50	281.5	0.4621	0.3778

+ Additives hBN	60	213.0	0.4600	0.3731
	70	180.0	0.3859	0.3103
	80	135.7	0.2852	0.3275
	90	124.5	0.2592	0.2051

Table 1: Observation

B. Observation Graphs

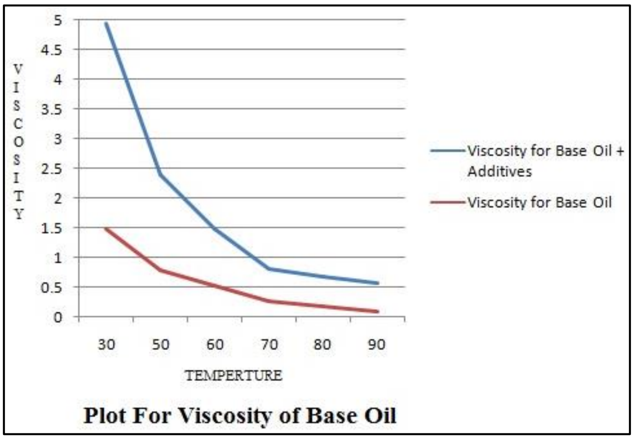

Fig. 5:

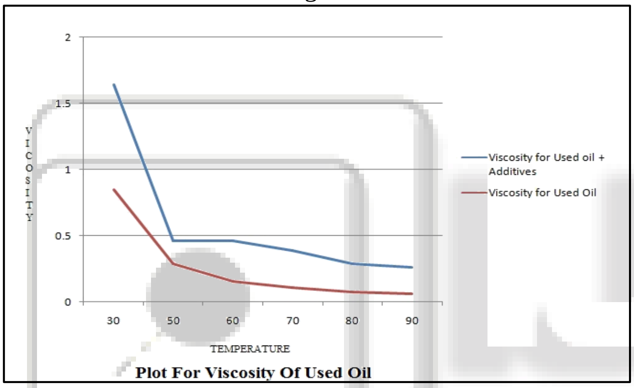

Fig. 6:

V. CONCLUSION

The hBN nanoparticle Oxides is significantly reduce the coefficient of friction and wear of friction pairs and will increase Extreme Pressure properties significantly. hBN plays important role in viscosity.

As the viscosity of used oil increase by 30-40% we can reuse the used oil again.

This shows that the nanoparticles has the potential of acting as a performance enhancer (additive) in the lubricant. So to achieve better properties determining the appropriate concentration is a very important

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