DEVELOPMENT AND CHARACTERIZATION OF LUBRICATING OIL FROM PETROLEUM BASE SOURCE (500N)

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Abstract

Lubricating oils were formulated from a petroleum base oil (500N oil) obtained from Nigerian National Petroleum corporation (NNPC) using simplex lattice design. Subsequently, the lubricant samples were characterized according to ASTM methods to define the following physicochemical properties: kinematic viscosity (at 40°C and 100°C), specific gravity, API gravity, viscosity index, flash point, pour point, total base number and appearances. The results showed that the samples were of the motor oil grades of SAE 30, SAE 40 and SAE and 20W50 based on their viscosities. Samples 5 and 6 of SAE20 and W50 grades were the best since they have specifications close to the acceptable standards world wide with viscosity indices of 126 and 124, respectively,

Introduction

Lubrication is simply the use of a material to improve the smoothness of movement of one surface over another, and the material which is used this way is called a lubricant. Lubricants are usually liquids or semi-liquids or semi solids, but may be solids or gases or any combination of solids, liquids and /or gases(Lansdown, 1982). No surface, however polished, is ideally smooth,. though modern machinery is capable of producing finished surface that approach perfection(Mahmood, 1977). When one surface move over another, there is always some resistance to movement and the resisting force is called friction. This friction, if low and steady, there will be smooth, easy sliding. At the other extreme the friction may be so great or so uneven, that movement becomes impossible and the surfaces can overheat or seriously damage.

The overall importance of lubrication is to ensure that, the economic and design of equipment, machinery and plant are operated at minimum costs through the following functions.

1. to maintain an oil film between moving parts so as to minimize the frictional effect of metal to metal cortex.
2. to act as a cooling medium by absorbing dissipating excessive heat generation.
3. to remove dirts from engine parts thus keeping them clean and efficient

Lubricating oil must perform the above functions in an automobile engine. Apart from these functions, it must also protect the metal as much as possible from rusting, corrosion surface damage and wear(Gruse, 1982).

The characteristics and performance of lubricating oils depend on the crude oil source, formulating method, base stocks and chemical additives (Aibe, 1998; Oyekunle and Oyeleye, 1986). Basically, there are two types of lubricating oils normally used for engine lubrication, namely petroleum based fluid and synthesis fluid. However, petroleum products have been found to excel as lubricant. They have high metal wetting ability as well as better viscosity characteristic, basic requirement of a lubricating film. Petroleum lubricating oils also posseses many essential additional properties such as good water resistance, inherent rust preventive characteristic, material adhesiveness, relatively good thermal stability and the ability to transfer frictional heat from

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lubricating parts. Colors of lubricating oils vary from colorless, to dark red and this has no bearing upon the usefulness of oil for a given application, although it has been believed by some laymen that pale colour indicates high quality. Color is important in constant applications, such as the fertile industry where a dark colored oil stain in a bolt of cloth would be objectionable (Poporich and Carl (1959).

The basic petroleum lubricant simply referred to as base oil is a complex mixture of hydrocarbon molecules and is derived from the refining of crude petroleum residue from vacuum distillation that has a boiling point of 700-1000 "CF. It is available in a great variety of types and grades i.e (100N, 150N 50N andBS2).

The purpose of this work therefore is to formulate lubricating oils from petroleum base oil by statistical design rather than the simplistic unifactor approach used by today's oil designers which is always far from being optimum, This would ensue that lubricants with optimum performance are obtained. Also, the lubricants formulated will be characterized so as to specify their quality and grades as well as compare with the international standard.

2.0 Experimental Procedure

Materials:

The formulation was carried out using, 500N HVI base oil from Kaduna refinery, shelves (ethylene propylene copolymer), viscosity improver and paranox 5501 additive package.

Procedure

The oils were designed using simplex lattice design. The name lattice was used here simply to make reference to array of point. The lubricant component proportions were to satisfy the constraint;

$X_i = 0, x_1 + x_2 + x_3 + \ldots\ldots\ldots\ldots + x_q = 1.0$.(1)

Each component proportion x_i ranged from zero to unity, and all blends among the ingredients were possible.

The number of design points in the {q, m} simplex lattice is given as follows:

$$(\frac{q+m-1}{m}) = \frac{q+m-1}{m!(q-1)!}$$

Where m! is "m factorial" and

$m! = m(m-1)(m-2)\ldots\ldots\ldots\ldots$ (2)

The symbol (^a_b) is the combinational symbol for the number of ways "a" things could be taken "b" things at a time and,

$$(^a_b) = (\frac{a!}{b!(a-b)!})$$

The [3,3] simplex lattice used in this work consisted of

$(\frac{3+3-1}{3}) = \frac{5!}{3!2!} = 10\,pionts$ and these corresponded to single component mixture, to binary or two component mixture, to tertiary or three components blend.

The samples were blended using pilot blending machine of the Unipetrol Lube Blending Plant laboratory, Kaduna, Nigeria, at temperature not more than 60°C.

2.3 Determination of Oil Sample Properties

Specific Gravity

The specific gravity of each sample was determined at 15°C with hydrometer cylinder.

Viscosity

The kinematic viscosities of the samples were measured with a calibrated Cannon Fenske Viscometer at 40°C and 100°C, respectively, with required estimated viscosity and flow time of not less than 200seconds..

Flash Point

The flash points of the samples were determined with Cleveland Semi Automatic Apparatus (Cleveland open cup) and values were obtained at various temperatures.

Pour Point

The pour point was determined with SETA-LEC Cloud and Pour Point Refrigerator. In each case, 3°C was added to the temperature recorded according to the standard and result was reported as the pour point.

Total Base Number

The total base number was determined with Potentiograph Apparatus. The apparatus was adjusted in accordance with manufacturer's instruction and titrated at a speed of 1.0ml/min.

The end point of the titration was recorded as the total base number.

Appearance

Visual method was used to determine the appearance of the samples and results were recorded.

Water Content

Each sample was weighed and heated to a temperature of about 110°C for 2minutes. The samples were removed, cooled and reweighed. The difference in weight before and after heating of the sample was used to determine the percentage water content.

2.3.8 Viscosity index and API gravity

ASTM corrective methods were employed to obtain their values for each sample.

Results and Discussion

Table 1: Various Formulations used for the Statistical Design

Composition of Lubricants

Formulation no	1	2	3	4	5	6	7	8	9	10
500N/g(X_1)	1.0	0.873	0.86	0.835	0.82	0.85	0.87	0.88	0.873	0.871
Viscosity Improver/g(X_2,0		0.127	0.14	0.10	0.12	0.08	0.07	0.06	0.065	0.068
Additive package/(X_3)0		0	0	0.065	0.06	0.07	0.06	0.06	0.062	0.06

$$\sum_{\tau=1}^{3} X\tau = 1.0$$

Table 2: Physicochemical Properties of Lubrications

Formulation no Lubricant properties	1	2	3	4	5	6	7	8	9	10
Appearance	Bright & Clear	Bright & Clear	Bright & Clear	Bright & Clear	Bright & Clear	Bright & Clear	Bright & Clear	Bright & Clear	Bright & Clear	Bright & Clear
Specific gravity at 150°C	0.8814	0.8906	0.892	0.8897	0.8021	0.8884	0.8889	0.8885	0.8887	0.8888
Kinematics' viscosity st, at 40°C	93.37	140.41	145.99	202.83	206.39	199.43	182.64	175.96	172.22	175.27
Kinematic viscosity st at 100°C	10.88	14.71	15.25	20.90	21.63	20.97	19.26	18.78	18.59	19.07
Viscosity index (VI)	100	104	106	122	126	124	120	120	121	124
Total base number (mg KOH/g)	0	8.78	9.77	6.89	8.36	5.64	4.85	4.19	4.49	4.72
Flash point, coc°C	242	228	230	230	236	232	226	230	234	236
Pour point, °C	-7	-8	-9	-7	-9	-10	-10	-11	-8	-8
API gravity, (150°C)	29.0	27.4	27.1	27.5	27.1	27.8	27.7	27.8	27.7	27.7
Water content(% Vol)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Table 3: NIS Requirements for Engine Lubrication Oil.

	Specifications		
Characteristic	Single grade SAE 30	Single grade SAE40	Multi-grade SAE 20 W 50
Appearance	Bright & Clear	Bright & Clear	Bright & Clear
Specific gravity at 15°C	0.87-0.898	0.899-0.910	0.893-0.889
Kinemetic viscosity at 100°C cst ($mm^{2/s}$)	10.2-12.9	13.5-16.8	17.1-22.0
Viscosity index (VI) min.	95	95	125
Total base number mg KOH/g, (min).	5.0	5.0	5.0
Water content, % vol max.	0.025	0.025	0.025
Flash point, COC, °C (min)	204	204	204
Pour point, °C (max)	-18	-9	-23

Table 1 shows the various quantities of the components used in the lubricant formulation. The combinations ranged from pure or single component, to binary or two components to ternary or three components.

The physical properties of the lubricants obtained from the analysis were tabulated as shown in Table 2.

From the table, the appearance of the samples are bright and clear and is conformity with the literature value (Table3).

The specific gravities measured at 150°C are 0.8814, 0.8904, 0.892, 0.8897, 0.8921, 0.8884, 0.8889, 0.8885, 0.8887, and 0.8888. respectively, for samples I to X. These values are also in conformity with literature values (Table3),except for samples 2 and 3 which are a little bit low but are still considered reasonable. This discrepancy may be attributable to little error in the experimental procedure. The corresponding API gravities are within the literature values of the range 24-30(Aibe, 1998).

The Kinematic viscosity of the sample which is the major grading property of lubricants' was used in classifying the lubricants into grades. From Table.2, the lubricants values fall within the various range of the literature values. For instance. Sample I falls within the SAT 30 range, sample 1and 2 fall within SAE 40 and sample 5 to 10 fall within the SAE 20 W 50 multigrade oil.

The viscosity indices of the sample are 100,104,106,122,126,124,120,120,121 and 124 for samples 1 to 10, respectively. The values for sample 1, 2, 3 and 5 fall above the minimum value (Table 3) of which the others are a little bit lower but are still considered reasonable. Viscosity Index of sample V is of the highest values and the additive package used in its formulation is also of the highest value. This means that the lubricant will tend to display less change in viscosity at high temperature and invariably gives best performance.

The literature value for total base number is 5.0mgKOH/g minimum. From the result obtained, samples II, III, IV, V and VI are above the minimum value. Sample VII and X are not far from the value too (Table 3). The value of sample VIII and IX are a little bit low. This is due to the amount of additive package used in their formulation. The implication of low total base number is that the lubricants can easily degrade while in-service.

The flash points of the lubricants were above the literature minimum range of 204. These values indicate the absence of highly volatile and flammable materials, whereas the pour points of the lubricants are -7°C, -8°C, -9°C, -7°C, -10°C, -10°C, -11°C, -8°C,-8°C, and -8°C,I-X, respectively. The values indicate the lowest temperature at which the oils could be used for certain applications. From the results, it could be seen that sample IV-X have high pour point value when compared with the literature value. This may be attributed to the amount of wax present in the oil.

The water content of the lubricants is zero percent per volume of lubricant . This value is below the maximum value of 0.025 (Table 3) and is supportive of the excellent composition of the samples and hence represents a good formulation. The zero percent value indicates the complete absence of water in the lubricants.

Conclusion

It can be concluded that formulated samples (i.e. pure blend and binary blend) met the viscosity requirement of the motor oils grades that have best results, since their properties are very close to the literature standard with viscosity index of 126 and 124, respectively.

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