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EFFECTS OF USED LUBRICATING OIL ON THE PROPERTIES OF LOW POUR FUEL OIL

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ABSTRACT

Effects of used lubricating oil on selected properties of low pour fuel oil (L.P.F.O) have been evaluated. The fuel oil was blended with used automotive crankcase oil at sample to used oil ratios of 9:1, 8:2, 7:3, 6:4 and 5:5. L.P.F.O analysis resulted in the following physicochemical properties: heat content (42.87 MJ/kg), kinematic viscosity at 70 °C (20.50 cSt), density at 15 °C (0.9601 kg/l), sulphur content (0.3295 wt%), water content (1.80 vol%) and ash content (0.073 wt%). The values obtained for used oil were lower than those of the blend. The physicochemical profile of L.P.F.O with increasing used oil blends indicated the following ranges: heat content (43.20 - 51.17 MJ/kg), kinematic viscosity at 70 °C (19.89 – 15.57 cSt), density at 15 °C (0.9430 – 0.10106 kg/l), sulphur content (0.3297 – 0.4821 wt%), water content (1.70 – 0.80 vol%) and ash content (0.069 – 0.055 wt%). Physicochemical profile of fuel oil blends showed the desirability of the blending as a positive influence on the heat content of fuel oil. Considering the need to utilize the observed positive effect of used oil additions on the heat content of fuel oil without seriously altering its physicochemical properties, a fuel oil to used oil ratio of 7:3 is recommended as an appropriate blend that could serve as a cost effective method of achieving the desired used oil properties, and thus serve as an appropriate method for used oil disposal.

KEYWORDS: Used automotive crankcase oil, lubricating oil, low pour fuel oil, heat content

INTRODUCTION

Fuel oil consists largely of the residue from the fractional distillation of asphaltic types of crude oil. The properties of fuel oils depend on the refining practices employed and the nature of crude oils from which they are produced. In marine ambient environment where fuel oils are utilized for heating purposes, low pour fuel oils are preferred. The pour point of oil is the lowest temperature at which oil will pour or flow when it is chilled without disturbances. Grades of fuel oils cover oils intended for use in various types of fuel oil burning equipment under various climatic and operating conditions (ASTM, 1989). Low pour fuel oil does not easily congeal and the cost of preheating is low. Fuel oils are generally used for steam raising, firing furnaces and boilers.

Petroleum is an excellent source of lubricants as a wide range of them varying in molecular weight from 250 to over 1000 could be obtained using various refining processes (Larson, 1992). The lubricant fraction is a complex mixture consisting not only of paraffins but also naphthenic and aromatic compounds with substantial paraffinic side chains. Lubricating oil is required by most equipment with moving parts. Its use cuts across light machines, internal combustion engines, heavy gears and many industrial systems. As tribological complexities increase, lube oils are made to meet the frictional challenges. Friction leads to increase in temperature at the contacting surfaces and subsequent heat transfer to the surroundings. Friction and wear have been identified as principal tribological problems which are of great concern (Halling, 1975). The wearing of metals, the seizure of metallic surfaces and the attendant heat release in automotive engine reinforce the need for some lubricating media to be provided. Lubrication is thus the practice in which surface-to-surface contacts of bodies in relative motion are reduced by application of lubricants (Bent *et al.*, 1974). The suitability of a lubricant for lubricating purpose depends on service conditions to be met and these are usually influenced by machine design, operating practices and quality of maintenance.

Automotive crankcase oil is generally designed to provide adequate lubrication, serve as coolant and sealant; minimize corrosion and keep the engine clean (Ofunne *et al.*, 1991). To effectively perform the highlighted functions, lubricants are formulated from base oils of appropriate viscosity and relevant additives incorporated (Ofunne *et al.*, 1989). Oils, however, do deteriorate in service. During engine operation, crankcase oil is subjected to a variety of changes which lead to its ageing and thus unfit for further lubrication use. This results in the accumulation of used lubricating oils, the disposal of which has been a subject of continuing interest. In Nigeria, for instance, improper disposal of used oil is one of the major sources of environmental pollution. Used oil hardly decomposes and contains trace metals and toxic substances. Oil dumped on land reduces soil productivity while films of oil on the surface of water prevent the replenishment of dissolved oxygen, impair photosynthetic process and block sunlight. The increasing cost of lubricating oils and the stringent environmental regulations on the use and disposal of same (Ofunne and Maduako, 1992) have necessitated the need for more researches. The present studies are aimed at evaluating the blending effects of used oil on the quality of low pour fuel oil.

MATERIALS AND METHODS

Materials

The tests were carried out using low pour fuel oil and used automotive crankcase oil. The fuel oil was obtained from Port Harcourt Refinery, Nigeria, while used oil was collected from an automechanic shop along Choba road, Port Harcourt. All the reagents were of analytical grades.

Methods

Fuel oil and used lube oil were separately analyzed for selected physicochemical parameters. The fuel oil was subsequently blended with used lube oil at fuel oil to used oil ratios of 9:1, 8:2, 7:3, 6:4 and 5:5. Effects of used crankcase oil on the properties of low pour fuel oil were evaluated using relevant ASTM methods (ASTM, 1989). Low pour fuel oil and its blends were analyzed for kinematic viscosity, density, sulphur content, water content, ash content and consequently heat content.

Estimation of Heat Content

Heat content is usually determined by burning a weighed sample in an oxygen-bomb calorimeter under controlled conditions. However, heat content could also be estimated where estimates are considered acceptable. The gross heat of combustion or heat content of the fuel and used

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oil was empirically determined using the equation

$$Qv\ (MJ/kg) = (51.916 - 8.792d^2)\ (1 - (x + y + s)) + 9.420s$$

where, Qv = gross heat of combustion at constant volume, MJ/kg

d = density of sample, $kg/m^3 \times 10^{-3}$
x = mass fraction of water (% divided by 100)
y = mass fraction of ash (% divided by 100)
s = mass fraction of sulphur (% divided by 100)

Results and Discussion

Some physicochemical properties of low pour fuel oil and used lube oil are presented in Table 1 while blending effects of used lube oil on these properties of fuel oil are shown in Table 2.

Table 1: Physicochemical Properties of Low Pour Fuel Oil and Used Lube Oil

Parameters	Low Pour Fuel Oil	Used Lube Oil
Kinematic viscosity at 70 °C (cSt)	20.50	12.57
Density at 15 °C (kg/l)	0.9601	0.8917
Sulphur content (wt%)	0.3295	0.5852
Water content (vol%)	1.80	0.05
Ash content (wt%)	0.073	0.043
Conradson carbon residue	5.00	1.00
Heat content (MJ/kg)	42.87	44.67

Table 2: Physicochemical Profile of Low Pour Fuel Oil (L.P.F.O) Blends

Blend Ratio (LPFO: Used Oil)	Kinematic Viscosity at 70 °C (cSt)	Density at 15 °C (kg/l)	Sulphur Content (wt%)	Water Content (vol%)	Ash Content (wt%)	Heat Content (MJ/kg)
9:1	19.89	0.9430	0.3297	1.70	0.069	43.20
8:2	18.78	0.9428	0.3587	1.50	0.067	43.29
7:3	17.30	0.9327	0.3816	1.40	0.058	43.48
6:4	16.89	0.9324	0.4175	1.20	0.057	43.56
5:5	15.57	0.10106	0.4821	0.80	0.055	51.17

Kinematic viscosity values at 70 °C indicated that L.P.F.O was more viscous than used lube oil. This showed that more of the molecular weight compounds were present in fuel oil. Viscosity of fuel oil is highly significant since it indicates the relative ease with which the oil will flow and its ease of atomization (ASTM, 1989). Water content, ash content, conradson carbon residue percentage and density values of L.P.F.O were observed to be higher than the corresponding used oil values. Used lube oil, however, had higher heat and sulphur contents. Our findings showed a direct relationship between densities and kinematic viscosities of L.P.F.O and used lube oil. The higher ash content obtained for fuel oil revealed the presence of more ash forming materials in fuel oil, thus extraneous solids such as dirts and rust expected in used oil were not sufficient factors of influence. This scenario was further reflected by the conradson carbon residue.

The physicochemical profile of L.P.F.O blends indicated that increasing used oil blend ratios led to increase in heat content. These observations correlate with our findings that used lube oil had higher heat content than L.P.F.O. In this study, a marked increase in heat content was observed when equal amounts of the oils were blended. The increasing heat content profile of fuel oil blends showed that the bulk of the obtained blends fell within the range of separately analyzed values of L.P.F.O and used oil. This positive effect of used lube oil on energy values of oil blends is significant as heat content is a very important property of fuel oil (US Department of Energy, 2004). Heat content is a measure of the energy available from a fuel and a knowledge of its value is essential when considering the thermal efficiency of equipment for producing either power or heat (ASTM, 1989). A rise in sulphur content may have an undesirable effect as increasing amounts of unwanted sulphur compounds could be produced (Radojevic *et al.*, 1999). The decreasing kinematic viscosity profile noticed could negatively affect heating capacity of fuel oil. Although the density of fuel oil reduced with increasing used oil addition, a striking phenomenon was noticed when equal amounts of both oils were blended. Indeed, the highest density of 0.10106 kg/l was recorded at equal blending ratio. The decreasing ash content profile was also surprising as used oil was expected to introduce more extraneous solid materials into the fuel oil blends (Radojevic *et al.*, 1999). Considering the need to utilize the observed positive effect of used oil additions on the heat content of fuel oil without seriously altering its physicochemical properties, a fuel oil to used oil ratio of 7:3 is recommended as an appropriate blend that could serve as a cost effective method of achieving the desired used oil properties, and thus serve as an appropriate method for used oil disposal. It is concluded that the extent of contamination of fuel oil depended on the amount of used oil introduced. Physicochemical profile of fuel oil blends, however, showed the desirability of the blending as a positive influence on the heat content of fuel oil. This could serve as an appropriate method for used crankcase oil disposal.

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