VISCOSITY PROBLEMS OF LOW SULPHUR DIESEL FUEL

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Abstract

The aim of the present study was to investigate the possible means of improving upon the antiwear behavior of severely hydrodesulphurized and gas condensate diesel fuels.

To achieve this target, the viscosities of the various diesel fuel samples were determined at 40 ºC using a glass viscometer. Subsequently, the fuel samples were formulated with some selected additives so as to determine the effect of these additives on the viscosity of the fuel samples at 40 ºC.

Finally, the lubricity of the formulated fuel samples was determined at 20 ºC using the high frequency reciprocating rig machine (HFRR).

The results obtained from the investigation revealed that at 0.5% Vol addition of hydrocarbon based additives, a significant reduction in the wear scar diameter was observed indicating that there was no need adding the additive above this value.

Keywords: low sulphur diesel fuel, gas condensates, viscosity, formulation, additives, lubricity.

Introduction

The sharp increase in the consumption of diesel fuels has put a question to the improvement of its quality. In the specifications on diesel fuels (Akasaka Y., Sakurai Y. 1998), the concentration of sulphur-containing compounds and aromatic hydrocarbon has been greatly reduced due to their adverse impact on the environment. The reduction in the concentration of this group of compounds can bring about a decrease in the viscosity of the fuel - an important performance measuring parameter. In some countries, gas condensate diesel fuel is widely used. Apparently, the advantage is an ultra low concentration of sulphur-containing compounds and aromatic hydrocarbon (which promotes the reduction of poisonous emissions in exit gases). However as noted above, introduction of gas condensates in the composition of diesel fuel greatly reduces its viscosity. Viscosity of the fuel must be such as to provide its normal injection and spraying in the combustion chamber of the engine, as well as improving the efficiency of the filtering system. With poor viscosity, the lubricity of the fuel falls. Lubricity is the ability to reduce friction between solid surfaces in relative motion. The lubrication mechanism is a combination of *hydrodynamic lubrication* and *boundary lubrication* (Garrett T.K., 1994).

In hydrodynamic lubrication, a layer of liquid prevents contact between the opposing surfaces. For diesel fuel pumps and injectors, the liquid is the fuel itself; and viscosity is the key fuel property. Fuels with higher viscosities will provide better hydrodynamic lubrication. However, diesel fuels with viscosities within the ASTM D 975 specification range (George V. D. 1993) provide adequate hydrodynamic lubrication. When high load and/or low speed has squeezed out much of the liquid that provides hydrodynamic lubrication, boundary lubrication becomes important. Now, small areas of the opposing surfaces are in contact. Boundary lubricants are compounds that form a protective anti-wear layer by adhering to the solid surfaces.

The use of fuels with poor lubricity can increase fuel pump and injector wear and, at the extreme, cause catastrophic failure. Such failures occurred in Sweden in 1991, when two classes of "city" diesel with very low sulfur and aromatics contents were mandated. Heavy hydrotreating was necessary to make these fuels. The problem was solved by treating the fuel with a lubricity additive. Many diesel fuels are good boundary lubricants. This is attributed to trace amounts of sulphur-containing compounds and certain classes of aromatic compounds. Evidence for the role of trace quantities is the fact that the lubricity of a fuel can be restored with the addition of as little as 10 ppm of an additive.

In this present study therefore, the target was to formulate some diesel fuel samples using some selected hydrocarbon based additives. Subsequently the samples were subjected to some standard tests to determine the effect of the additives on the antiwear behavior of the fuel samples.

Experimental Procedure

The experiment involved formulating the diesel fuel sample containing 0.02%W sulphur using different concentrations of some selected hydrocarbon based additives.

The kinematic viscosity of the control samples and the samples after different concentrations of additives had been added were determined. The experiment was carried out using the Russian standard known as GOST 33-82 (M. Universam 1994) which is equivalent to ASTM 445.

The procedure entails placing the sample in a calibrated capillary glass viscometer tube held at a closely controlled temperature (40°C). The time required for a specific volume of the sample to flow through the capillary under gravity is measured. This time is proportional to the kinematic viscosity of the sample. The kinematic viscosity is thus calculated from the formula:

$$\upsilon_t = C \cdot \tau_t$$

Where

C – a constant of the viscometer in сст/сек,;

τ_t – arithmetic mean of the flow time of the sample in seconds.

A laboratory method developed for evaluating how low viscosity diesel fuels tend to reduce wear which employs a four-sphere friction machine known as a *High-Frequency Reciprocating Rig (HFRR)* was then used to evaluate the lubricity of the fuel samples. The machine was operated at a temperature of 20 °C and a load of a 100N.

Results and discussions

The variation of viscosity of the fuel sample with various concentrations of the additives used is tabulated below:

Table 1: Effect of viscosity on the concentration of the fuel sample

Concentration of additive % Vol.	Viscosity of sample at 40 °C, мм^2/с			
	dewaxed distillate lube oil	mixture of *i*- ά olefins	mixture of *n*- ά olefins	lube oil KC 19
0,00	3,09	3,09	3,09	3,09
0,25	3,19	3,15	3,15	3,19
0,50	3,25	3,19	3,19	3,22
1,00	3,25	3,22	3,22	3,25
1,50	3,28	3,25	3,28	3,31
2,00	3,31	3,25	3,28	3,41
2,50	3,34	3,28	3,28	3,44
3,00	3,41	3,31	3,31	3,50
3,50	3,44	3,34	3,34	3,63
5,00	3,54	3,38	3,44	3,69

The study showed that all the additives tested improved the viscosity of the samples when used in low concentrations with lube oil KC-19 (a mark of compressor oil) showing a good improvement in the viscosity of the fuel tested. It has been found that fuels from gas condensates and ones that have been severely hydrodesulphurized have less good antiwear behavior than direct-distilled oil ones. The largest effect on the properties comes from the concentration of sulfur compounds, with much less effect from the viscosity and the aromatic hydrocarbon content.

The HFRR test showed all the additives investigated improved the fuel lubricity by at least 20%. Some HFRR studies indicate that fuels with up to 450-micron wear scar diameters at 60°C (380-micron at 25°C) will perform satisfactorily in all fuel injection equipment. However, other studies show that some fuels and fuel/additive combinations with values above this level still do not cause excessive wear. (George V. D. 1993)

Conclusions and recommendation.

The use of hydrocarbon based lubricity additives in formulating low-sulphur diesel fuels has the prospect of the improving the viscosity characteristics of the fuel as well as improving its lubricity. It can therefore be concluded that that at 0.5% Vol addition of hydrocarbon based additives, a significant reduction in the wear scar diameter was observed indicating that there was no need adding the additive above this value.

From the investigations carried out the most efficient additive in increasing the viscosity of the fuel was lube oil KC-19, compressor oil. However, the i-ά olefins are recommended for further studies as they may prove a better alternative.

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