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Role of Specification in Maximizing the High Speed Diesel Yield from Crude Oil

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ABSTRACT

Pakistan's indigenous production of POL products is deficit in kerosene and high speed diesel oil. In the year 1990-91, 0.42 million metric ton kerosene costing 160 million dollars and 2.6 million ton HSD costing 751 million dollars, were imported. This paper describes the possibility of "cutting deeper" into the high speed diesel oil fraction of the crude oil, for maximizing the yield, without affecting the present marketing specification.

INTRODUCTION

Specification may be defined as one set of minimum laboratory testing results that gives adequate control of product quality. Product quality is usually checked by (1) performance test and (2) laboratory inspection test. Performance tests are usually too expensive and may lack the necessary precision. Laboratory tests are relatively simple and also correlate closely with performance tests (Allinson, 1975).

High speed diesel oil is the middle fraction of the crude oil (Pope, 1975). It is collected between 160-380 ^{o}C during crude oil distillation. It is also obtained through cracking of heavy oil to meet the growing demand of diesel fuel (Salazar, 1986). The quality of diesel oil depends upon the refinery process and nature of the crude input. Various properties such as volatility, ignition quality, viscosity, stability, and gravity are used to characterize diesel oil. Additives may also be used to improve the cetane number or index. Pour point depressant may also be used to meet the low temperature performance. As more and more attention is paid to atmospheric pollution, anti smoke additives are being used in advanced countries to reduce the exhaust smoke. HSD produced by cracking process, may contain anti-oxidant and sludge disperssant to prevent the formation of solid insoluble material that could cause line and filter choking.

Diesel engine is a high compression self ignition engine. The fuel is ignited by heat produced as a result of the high compression and no spark plug is used. The diesel cycle consists of charging the combustion chamber with air, compressing the air and injecting the fuel, which ignites spontaneously, expanding the burnt gases and expelling the product of combustion. Variation in the fuel quality may affect the engine performance. Standards for HSD have been laid down by various countries in order to control the quality and engine performance. In this paper a heavier distillate (HVI-100) has been added in various proportions to HSD sample and the properties of these blends were compared to Pakistan Standard Institution (PSI, 1981) specification.

EXPERIMENTAL

Material

High speed diesel (HSD) and heavy distillate (HVI-100) were obtained through refinery sources.

Analysis

Various physical properties of the feed materials and blends were evaluated by using ASTM test procedures. Fiat diesel engine and generator were used for running test. Load on generator was varied up to 10 KW. Before running the test, engine was overhauled and after completion of this study various parts were inspected to see the effect of heavy distillate on them.

RESULTS

Ignition Quality

Ignition quality of a diesel fuel is best represented by cetane number. The cetane number of the fuel is the numerical result of an engine test designed to evaluate fuel ignition delay. The shorter the ignition delay period, the higher the cetane number of the fuel and the smaller the amount of fuel in the combustion chamber when the fuel ignites. Higher cetane number fuel causes lower rate of

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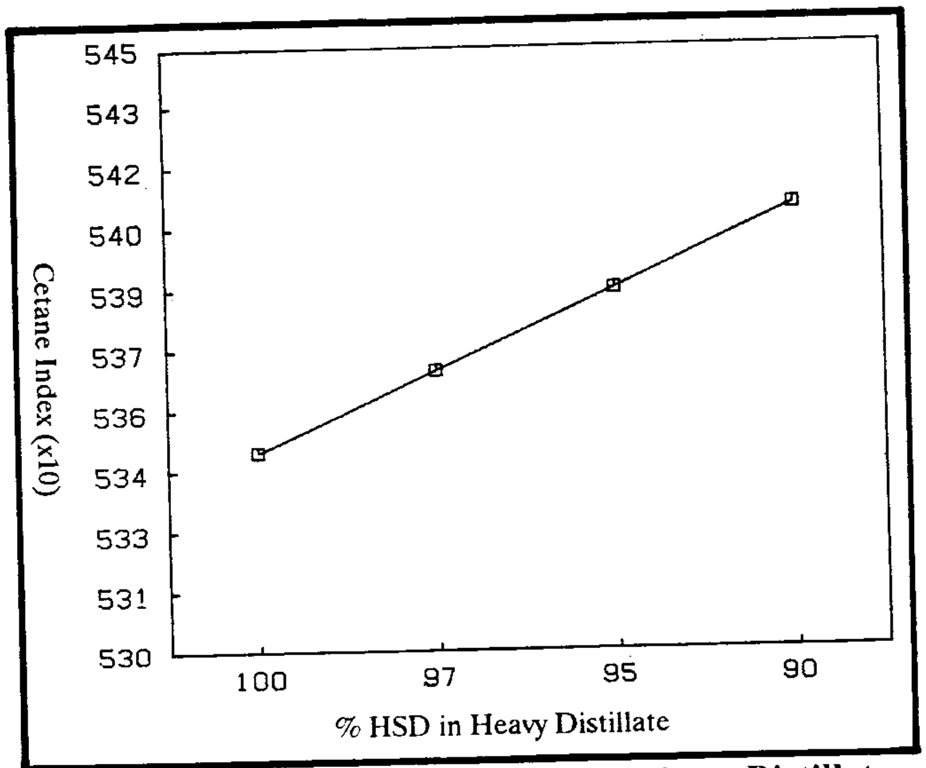

Figure 1— Cetane Index vs % HSD in Heavy Distillate.

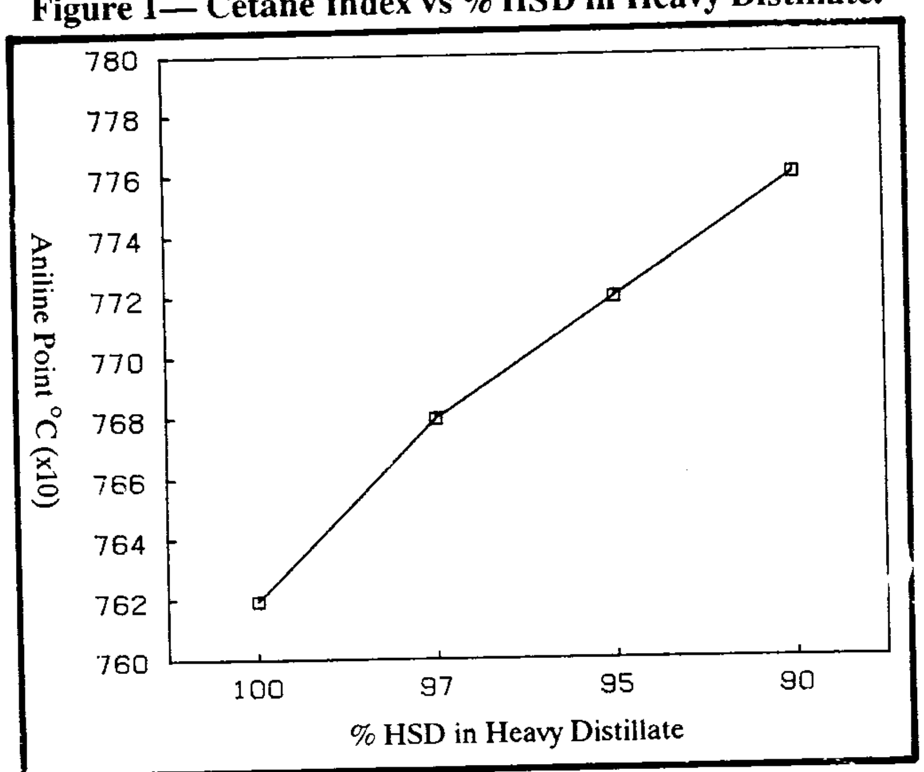

Figure 2— Anilline Point vs % HSD in Heavy Distillate.

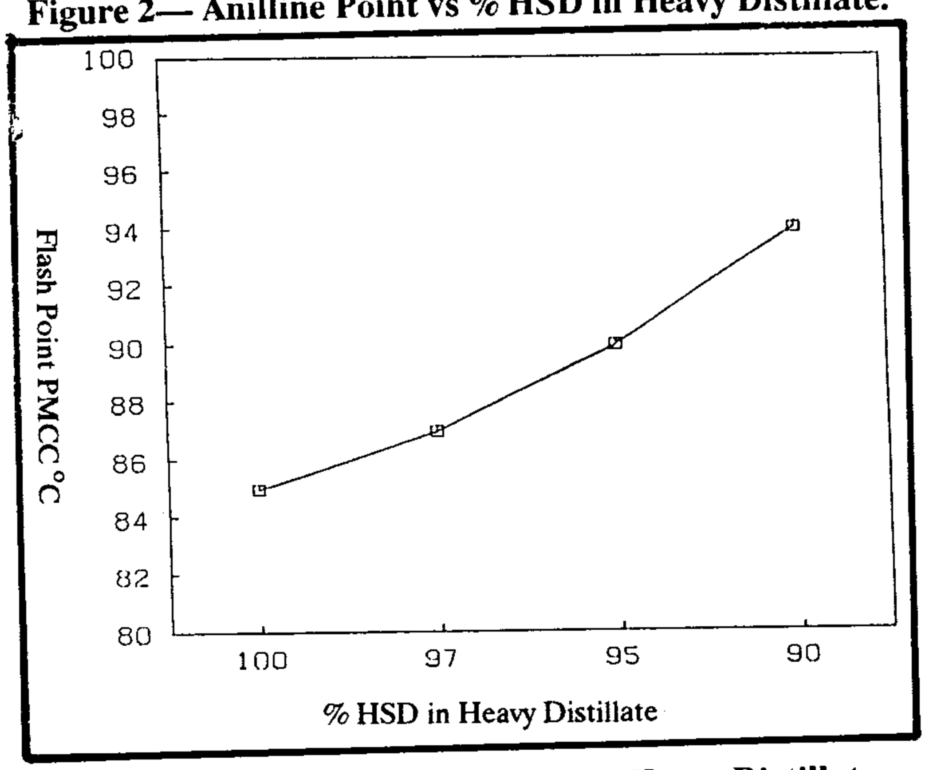

Figure 3— Flash Point vs % HSD in Heavy Distillate

pressure rise. The lower pressure results in lesser combustion noise, improved control of combustion and increased engine efficiency (Rosen, 1960).

The determination of cetane number involves expensive equipment and is also time consuming, therefore alternative methods have been developed. One of the most useful procedures involves the determination of cetane index, calculated with the help of API gravity and mid boiling point. Figure 1 relates the cetane number with percentage of heavy distillate in HSD. It is seen from the Figure 1, as more and more heavy distillate is added in the HSD, higher cetane number is obtained. PSI envisages a minimum of 45 cetane number. All the blends studied meet the PSI requirement of cetane number. PSI specification for High Speed Diesel oil (HSD) is given in Table 1. Properties of HSD and heavy distillate (HVI-100) tested in accordance with PSI specification are shown in Table 2.

Another test which indicates the ignition quality is the diesel index (Nelson, 1958). It gives a relationship between aniline point and API gravity. Aniline point is the lowest temperature at which the fuel is completely miscible with an equal volume of aniline. Figure 2 shows that aniline point increases as the amount of HSD decreases. Similarly, it can be inferred that gravity and diesel index also increased with the proportion of heavy distillate in the fuel.

Volatility

The volatility of a liquid may be defined as its tendency to change from liquid to vapor or gaseous state. There are a number of specific standards for determining the volatility of a petroleum product. For diesel fuel, only distillation and flash point give a good measure of volatility. The volatility requirement of diesel oil depends upon the engine size, design, load, speed variation and atmospheric conditions (ASTM D-2, 1971).

Flash Point of diesel oil increases as the quantity of heavy distillate is added (Figure 3). Usually lower limit of flash point is given in specification, therefore addition of a heavy distillate does not adversely affect the PSI specification.

Figures 4a to 4d show the distillation behaviour of HSD and various blends. Figure 4a summarizes the volume recovered at 365°C of different fuels. Initial and final boiling points of HSD and other blends were almost equal except with 10% heavy distillate where significant variation of these were noticed. The temperature of 50 percent recovery, known as mid boiling point, ranged from 280 to 306 °C, except for 10% heavy distillate blend where it was 315 °C. The fuel obtained by blending 97% HSD and 3% heavy distillate gave 91% recovery at 365 °C, whereas the fuel with 5% heavy distillate gave 89% recovery at this temperature, which was less by 1% as PSI requirement of minimum 90%.

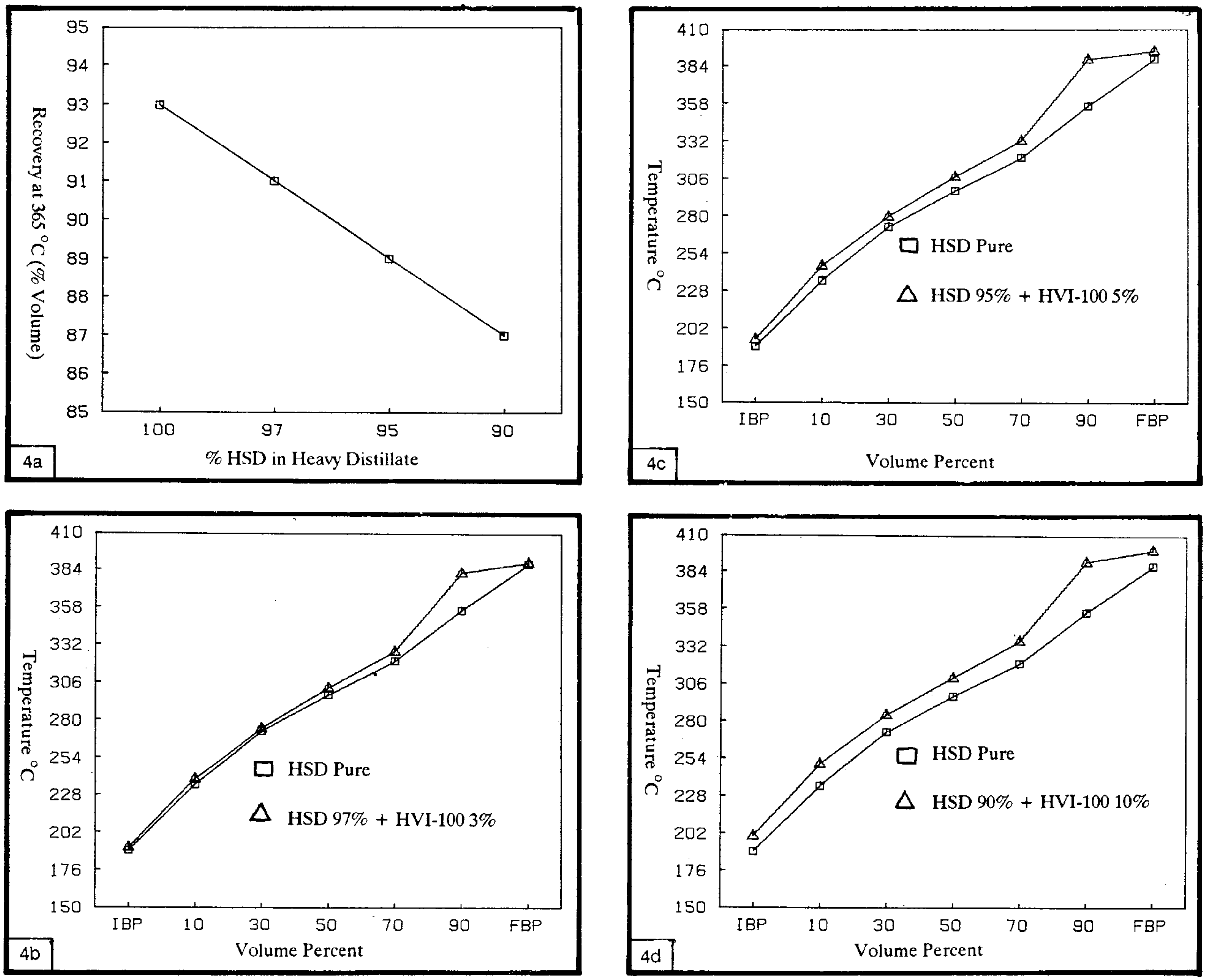

Figure 4(a-d)— Distillation behaviour of HSD and various Blends.

Flow Characteristics

Viscosity and pour point are the main tests which characterize the flow properties of HSD. High viscosity can cause poor atomization, large droplets and a jet of liquid stream instead of forming mist. As a result, fuel is not mixed properly with air for burning. On the other hand, with low viscosity fuel combustion is impaired resulting in reduced power output. Fuel viscosity for HSD ranged from 1.00 to 6.50 cSt at 40 °C. Viscosity increased as the proportion of heavy distillate was increased in HSD (Figure 5). It is seen from this figure that even 10% of the heavy oil in HSD had a viscosity of 5.01 cSt, which is well below the PSI limit of 6.5 cSt. Pour point is an indication of the lowest temperature at which fuel can be pumped. Pour point of the fuel increased as it was blended with heavy oil. It is seen from Figure 6 that all the blends studied conform to PSI specification for pour point.

Chemical Tests

Ash, carbon residue, sulphur and copper corrosion tests may be regarded as chemical examination of the fuel. Higher the value of these test results, poorer the quality of the oil. Therefore maximum limits of these results are defined in specifications. A close examination of the test results given in Table 1 and their comparison with PSI values, concludes that 5% blend easily conforms to specification. Conradson carbon residues of the fuels are given in Figure 7. It is seen that 10% blend of heavy distillate

Table 1. Pakistan Standard Institution specification for high speed diesel oil.

Characteristics	Unit	Requirement
Ash	Wt.%	0.01 Max
Cetane Index	-	45 Min.
Cetane Number	-	45 Min.
Cloud Point	°C	5 Max.
Conradson Carbon on 10% residue	Wt.%	0.2 Max.
Copper Corrosion 3 hrs. at 50°C	-	1 Max.
Distillation Recovery at 365°C	Vol.%	90 Min.
Flash Point (PMCC)	°C	60 Min.
Pour Point	°C	2 Max.
Sediment	Wt. %	0.01 Max.
Sulphur	Wt. %	1.0 Max.
Strong Acid Number	mgKOH/g	Nil -
Total Acid Number	mgKOH/g	0.5 Max.
Kin. Viscosity @ 40 °C	cSt	1.0 Min. 6.5 Max.
Water Content	Vol. %	0.05 Max.

Table 2. Properties of high speed diesel (HSD) and heavy distillate (HVI-100)

		HSD	HVI-100
Ash	Wt.%	0.006	0.07
Cetane Index	-	53.5	-
Cloud Point	°C	-3	0
Conradson carbon on 10% residue	Wt.%	0.01	0.31
Copper corrosion 3 hrs. at 50°C	-	1	1
Distillation recovery at 365 °C	Vol.%	93	5
Flash Point (PMCC)	°C	85	198
Pour Point	°C	-6	-3
Sediment	Wt.%	0.005	0.008
Sulphur	Wt.%	0.93	1.30
Strong Acid Number	mgKOH/g	Nil	Nil
Total Acid Number	mgKOH/g	0.05	0.05
Kin. Viscosity @ 40°C	cSt	4.43	19.43
Water Content	Vol.%	Nil	Nil

gave a residue value of 0.202 wt%. This is slightly higher than the PSI limit of 0.2 wt%.

Results of fuel consumption vs load on a stationary diesel engine are shown in Figure 8. It is interesting to note that at zero kilowatt, fuel consumption is same, but as the load is increased, the difference in fuel consumption becomes more prominent.

DISCUSSION

Addition of heavier distillate affected almost all the physical properties of the final blend. Cetane number, aniline point, flash point, kinematic viscosity increased gradually with addition of heavier distillate, showing an improvement in the properties of oil as a fuel. However, increase in pour point, decrease in recovery at 365 °C, high middle and final boiling points and increase in conradson carbon residue, showed a decline in the properties of the fuel. Some of these tests crossed the limit as proposed by PSI with 10% heavy oil blend. However it was encouraging to note that most of the test results conformed to PSI specification with 5% heavier blend.

Easier starting, particularly in cold weather and faster warm up are accomplished with fuel of higher cetane number. It also helps reduction of exhaust smoke and odour. Very high middle boiling point (305 °C) would cause smoke formation, lubricating oil contamination and promote engine deposit (Nelson, 1958). These are also true for high viscosity fuel. Low viscosity can lead to excessive leakage into the injection pump plunger, poorer combustion and power efficiency. Wear of the engine may increase, because lubricating properties of fuels tend to decrease with viscosity. High conradson carbon residue usually results in high carbon deposit in engine.

CONCLUSION

From this study it is concluded that cutting deeper into the heavier distillate (light lubricating base oil), the middle distillate (HSD) refinery slates can be increased upto 5% without any upset in the HSD specification as laid down by PSI, thus saving of foreign exchange equivalent to 5% HSD import can be achieved.

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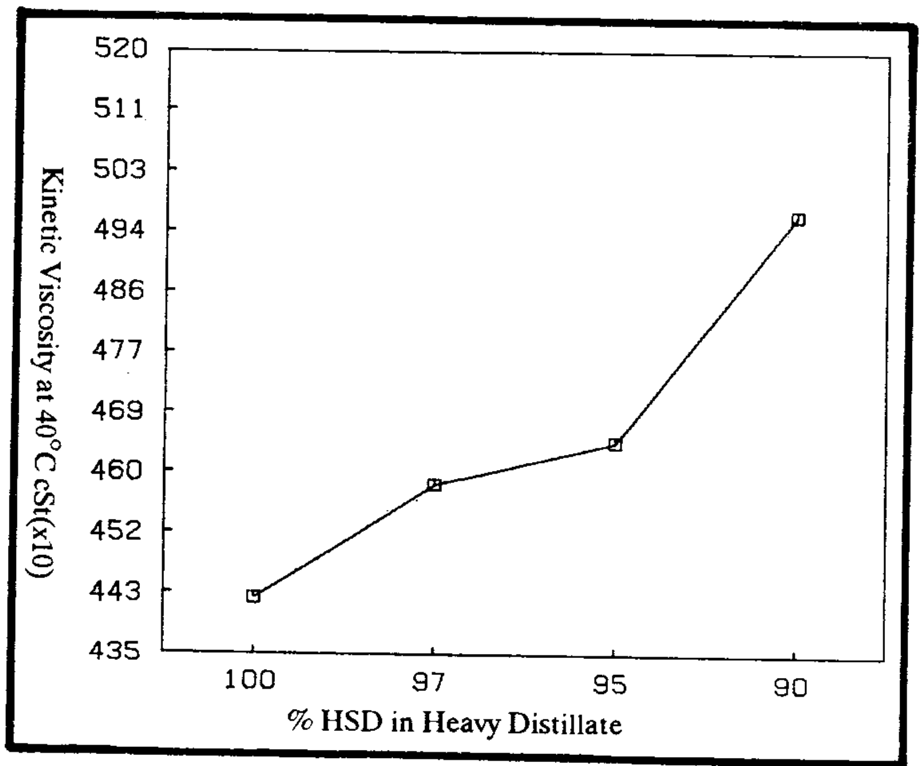

Figure 5— Kinetic Viscosity vs % HSD in Heavy Distillate.

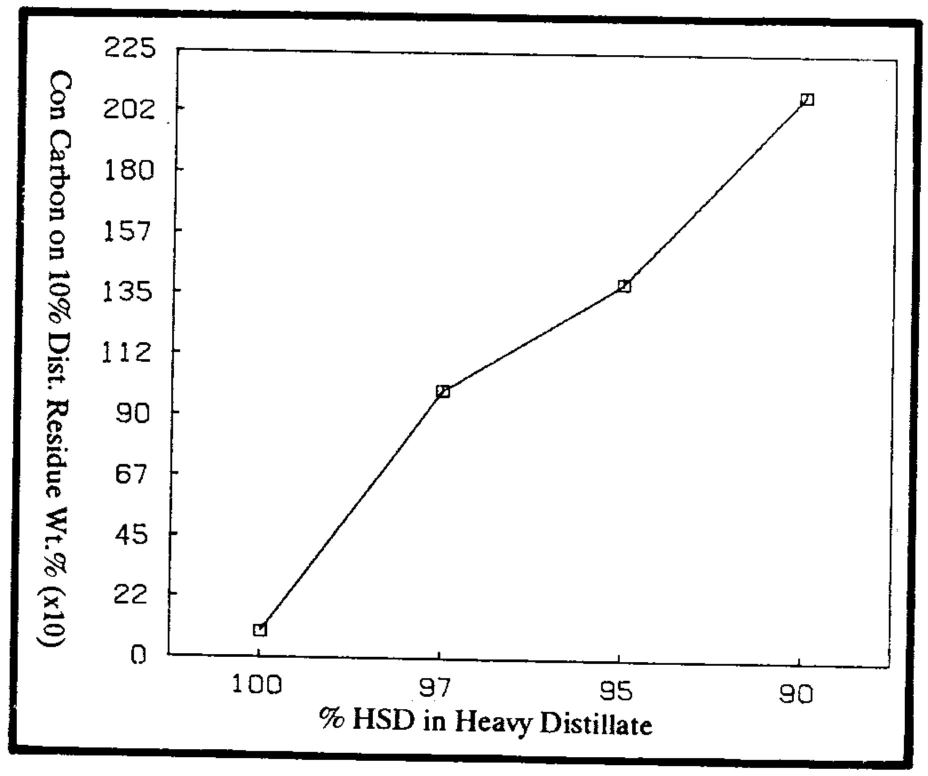

Figure 7— Conradson carbon vs HSD in Heavy Distillate.

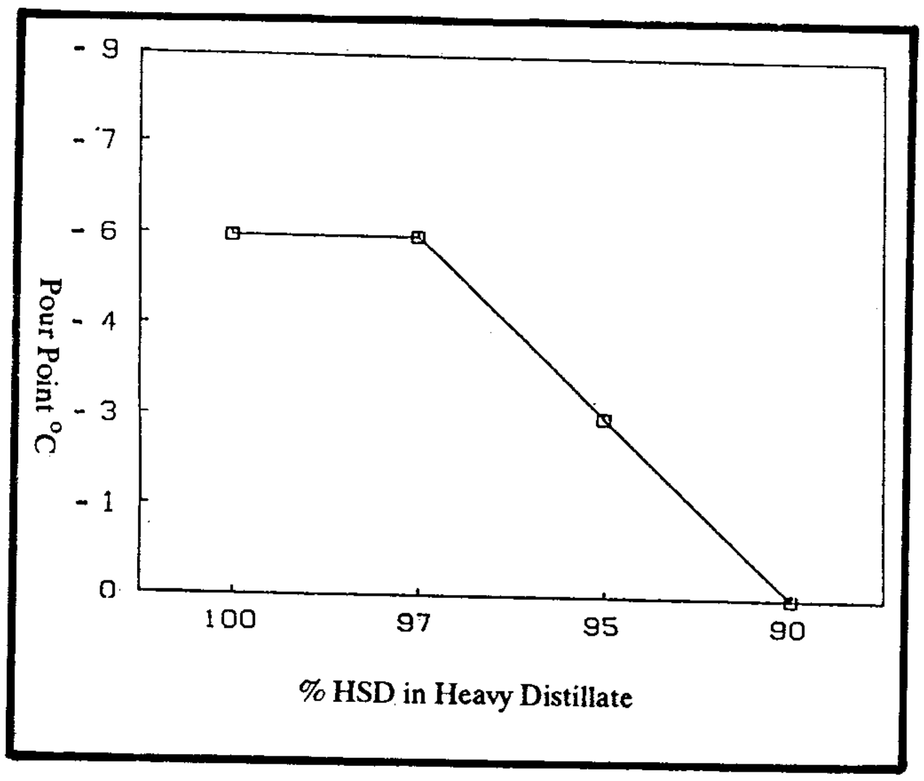

Figure 6— Pour Point vs % HSD in Heavy Distillate.

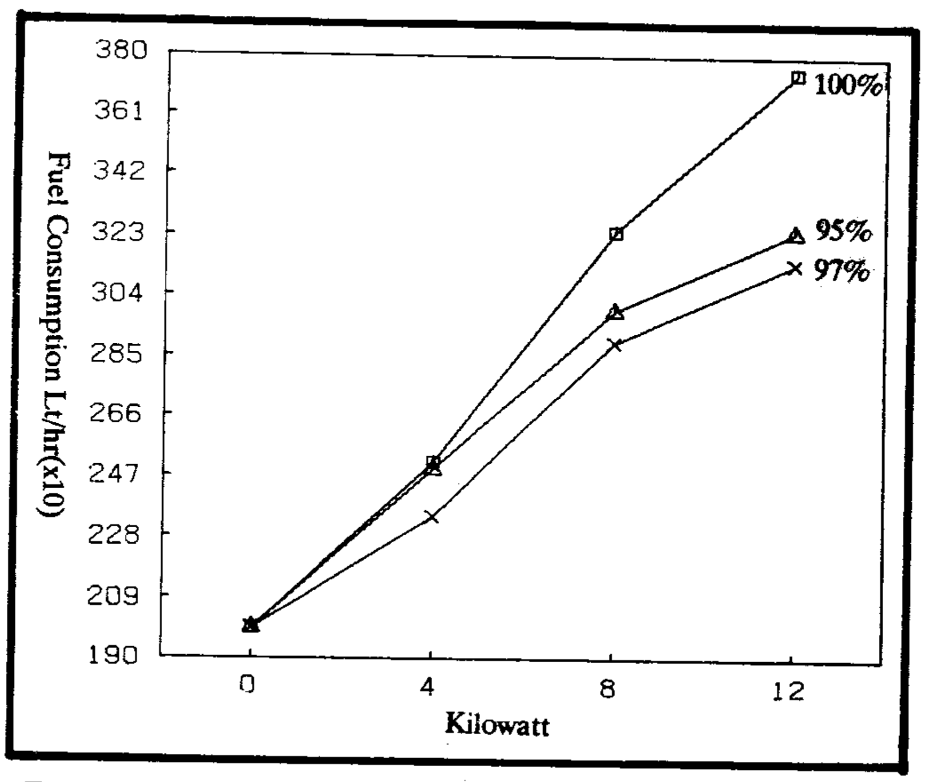

Figure 8— Fuel consumption of various blends vs load on a stationary diesel engine.

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