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Studies of the effect of Fuel stick on the Characteristics of high speed diesel (HSD)

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(Final Report)

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DEFINITION

A diesel fuel is any fuel suitable for burning in diesel or compression ignition engines. Petroleum diesel fuels may be distillates and residual fuels.

In a compression ignition engine, air alone is drawn into the cylinder and compressed until it is hot (about 500°C). At this stage, finely atomised fuel is injected at a very high pressure, which is ignited by the heat of compression and hence the term compression ignition (C.I.). A spark ignition engine on the other hand, relies upon a carburetor to supply into the cylinder a mixture of gasoline vapour and air, which after compression, is ignited by a spark.

The average compression ratio of a diesel engine is much higher (about 15:1) than that of a gasoline engine (about 8:1). This is the reason for the higher thermal efficiency of the diesel engine (about 35% as compared to about 25% of the gasoline engine) which makes for economy in operation.

NOMENCLATURE

Two main grades of diesel fuel are marketed in India, High Speed Diesel (HSD) and Light Diesel Oil (LDO) The former is a 100% distillate fuel while the latter is a blend of distillate fuel with a small proportion of residual fuel.

SPECIFICATIONS

HSD is currently marketed meeting Bureau of Indian Standards Specifications, IS 1460:2005 Specificatio for Diesel Fuels and AMENDMENT NO. 2 MARCH 2010 IS 1460: 2005 specification for diesel fuel.

From 1st April, 2010, 13 cities in India, Diesel fuel meeting Bharat Stage IV norms is available and in rest of country Diesel fuel meeting Bharat Stage III norms. The 13 designated cities cities are Delhi, Mumbai, Chennai, Kolkata, Bangalore, Hyderabad, Ahmedabad, Pune, Surat, Kanpur, Lucknow, Sholapur, and Agra.

END USE

HSD is normally used as a fuel for high speed diesel engines operating above 750 r.p.m. i.e. buses, lorries, generating sets, locomotive, pumping sets etc. Gas Turbines requiring distillate fuels normally make use of HSD as fuel. LDO is used for diesel engines, generally of the stationary type operating belo 750 r.p.m.

There are two grades of HSD, being marketed by Bharat Petroleum. These are HSD normal and Hi-SPEE – a premium branded HSD fuel.

Hi-Speed:

? Hi-Speed Diesel contains detergents that enhance combustion through a process of cleaning up of fuel injectors that are blocked with harmful deposits. This improves spray pattern and prevents the injectors from "dribbling" with diesel. These detergents not only clean the injectors but also prevent the formation of new deposits making it work as good as new, every time. By cleaning up these deposits the detergent additive restore and sustain original performance leading to increased power and better acceleration. The higher cetane number of 53 of Hi Speed Diesel ensures that it burns more smoothly and completely there by reducing exhaust emission, engine vibration and resultant noise as compared to normal diesel.

Hi-Speed HSD is currently marketed meeting Bureau of Indian Standards Specifications, IS 1460:20005 Specification for Diesel Fuels and AMENDMENT NO. 2 MARCH 2010 IS 1460: 2005 specification for diesel fuel.

SIGNIFICANCE OF PROPERTIES

1. Ignition Quality

When fuel is injected into the combustion chamber of a diesel engine, ignition does not occur immediately. The interval between the commencement of fuel injection and the commencement of combustion is known as the "Ignition delay" and is a measure of the ignition quality of the fuel. This delay period depends on the nature of the fuel, the engine design and on the operating conditions. If the delay is too long, the engine may be hard to start and when the accumulated fuel does ignite, the rate of pressure rise may be so great that it causes roughness or diesel knock. The effects of diesel knock are similar to the effects of knocking in gasoline engines viz. loss of efficiency and power output and a possibility of mechanical damage to the engine if the knocking is prolonged.

Addition Fuel Stick in High Speed Diesel (HSD), reduces or shortens the ignition delay, the engine runs smoother and improves the performance of the engine.

2. Cetane Number

The most accurate method of assessing the ignition quality of a diesel fuel is by measuring its cetane number in a test engine, the higher the cetane number the higher the ignition quality. The cetane number of a fuel is defined as the percentage of cetane, arbitrarily a cetane number of 100, in a blend with alphamethyl-naphthaline (cetane number-0) which is equivalent in ignition quality to that of the test fuel.

With Fuel Stick improvement in the cetane number is observed in fuel stick doped diesel HSD

3. Diesel Index

The cetane method of expressing ignition quality presupposes the availability of a standard engine, reference fuels and also tends to be somewhat time-consuming and expensive. Hence alternative tests, such as Diesel Index, is often used for routine control purposes.

The diesel index of a fuel is a non-fundamental property, which is calculated from the following formula:

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D.I. = Aniline Point (°F) x A.P.I.Gravity 100

A.P.I, (American Petroleum Institute), gravity is calculated from specific gravity (s.g.) as follows: -
API Gravity = 141.5 - 131.5
s.g. @ 60/60°F
Aniline point is the lowest temperature at which the fuel is completely soluble in an equal volume of pure dry aniline (a chemical liquid). A diesel fuel is a mixture of aromatics, napthenes and paraffins, which are the three basic types of hydrocarbons found in petroleum. Aromatics have low aniline point therefore low diesel indices and poor ignition quality, paraffins, on the other hand, have relatively high aniline points and good ignition quality. Naphthenes are intermediate in ignition quality.
There is a fair degree of correlation between cetane number and diesel index, the latter being generally higher by about 3 to 5 numbers throughout the entire range. This correlation breaks down if fuels of widely different composition are compared and also in the case of fuels containing ignition additives or "dopes". These additives are known as cetane number is checked in a standard engine.

4. Viscosity

Defined simply, viscosity means resistance to flow or movement. In metric system, centistoke is the unit for its measurement. It is function of time taken in seconds for a given volume of oil to flow through a calibrated viscometer under specified conditions. Viscosity depends on temperature and decreases as the temperature increases, so no numerical value has any meaning unless the temperature is specified. In the case of diesel fuels, low viscosity may give rise to:-

(i) Leakage of fuel from pumps and injectors.

(ii) Abnormal rate of wear of the moving parts of pumps and injectors owing to lack of lubricity.

(iii) Too fine a degree of atomisation with the result that the fuel will not penetrate sufficiently far into the compressed air in the cylinder to give the food mixing essential for efficient combustion.

(iv) Overheating of the injector owing to the concentration of the fuel spray and hence the flame in a relatively small area around the injector nozzle.

If the viscosity of the fuel is too high, it will impede the flow of fuel to the pump, giving rise to poor atomisation and excessive penetration with inefficient combustion of fuel.
Suitable lower and upper limits are therefore specified for viscosity of diesel fuels.

5. Carbon Residue

Different fuels have different tendencies to crack and leave carbon deposits when heated under similar conditions. This property is normally measured by the Conradson or the Ramsbottom coke tests. In these tests, a sample of the fuel is heated without contact with air under specified conditions and the weight of carbon residue remaining after the test is expressed as a percentage of the weight of the sample.

Broadly speaking the Ramsbottom carbon value appears to indicate fairly well, the tendency to form carbonaceous deposits on the injector tip of a diesel engine. This can become a serious problem in high speed engines and hence, a stringent limit is placed on Ramsbottom carbon in the case of HSD Oil.

Fuel Stick doped High Speed Diesel leaves minimum Carbon residue thus indicating that there is proper or near enough complete burning of diesel fuel in the engine.

6. Volatility

As a rule, the higher the viscosity of a liquid fuel, the lower its volatility. Therefore provided the viscosity lies within specified limits, a satisfactory volatility is automatically ensured. However, the percentage recovered at some particular temperature e.g. 366°C, is specified in the case of HSD mainly to control engine fouling due to incomplete combustion of the higher boiling components.

7. Total Sulphur

This is significant because it governs the amount of sulphur oxides formed during combustion. Water from combustion of fuel collects on the cylinder walls, whenever the engine operates at low jacket temperatures. Under such conditions, sulphurous and sulphuric acids are formed, which attack the cylinder walls and piston rings, promote corrosion and thus cause increased engine wear and deposits. The above effects can to some extent be overcome by the use of lubricants containing alkaline additives. If the diesel fuel is refined from a very high sulphur crude, it may become necessary to desulphurise it before marketing.
Total sulphur is expressed as a percentage of the weight of the fuel sample.

Addition of Fuel Stick reduces the Sulphur content in the diesel oil and this automatically helps in extending the engine life.

8. Corrosive Sulphur

It is important that diesel fuels shall be free of these sulphur compounds which in themselves attack metal parts of the engine or the fuel system. This characteristic is tested by the Copper Strip Corrosion Test, a severe discoloration or pitting of the polished strip indicating the presence of corrosive sulphur compounds in the fuel.

9. Total Acidity

This should be low in order that corrosion of melts in contact with the fuel during storage and distribution is minimised.

10. Inorganic or Mineral Acidity

Where diesel fuels are treated with mineral acid as part of the refining procedure, traces of mineral acid remaining in the final product would obviously be undesirable. However, zero limit is usually specified for this property.

11. Organic Acidity

This is due to acids of the naphthenic type, which are constituents of crude petroleum. Their presence in small amount is not necessarily an indication of improper refining or poor quality. Although much

weaker than mineral acids, they may attack galvanised metal and this is why the use of galvanised containers for the storage of diesel fuels is not recommended.

12. Ash Content

Ash is a measure of the incombustible material present in a fuel and is expressed as a percentage of the weight of the fuel sample. In the case of distillate fuels, it usually consists of rust, tank scale or sand, which settles out readily. Blends of distillate and residual fuel, e.g. LDO may additionally contain metal oxide derived from oil soluble and insoluble metallic compounds. Ash is significant because it can give rise to deposit problems such as abrasion, malfunctioning of injectors and high temperature corrosion, particularly with residual fuels.

13. Sediment and Water

These are obviously undesirable contaminants and should be as low as possible.
The higher the specific gravity and viscosity of a fuel, the grater the quantities of water and sediment it can hold in suspension. Large quantities of sediment can affect the combustion of the fuel, and if abrasive, my cause excessive wear of closely fitting parts of fuel pumps and injectors. It may also clog filers and build up deposits in tanks and piping.

14. Pour Point

The pour point of a fuel is the lowest temperature at which it will pour or flow when chilled under prescribed conditions. It is a very rough indication of the lowest temperature at which a given fuel can be readily pumped. However, since practical conditions are quite different from those under which the laboratory test is conducted, many fuels can be pumped at temperatures well below their laboratory pour point.
Sometimes the cloud point is measured. This is the temperature at which paraffin was begins to crystallise or separate from solution when the fuel is chilled under prescribed conditions. This may settle out in the fuel system and cause blockage of filters – leading to malfunctioning or stalling of the engine.

15. Cold Filter – Plugging Point

The cold filter plugging point (CFPP) is defied as the highest temperature at which the fuel, when cooled under prescribed conditions, either will not flow through the filter (45 microns) or will require more than 60 seconds for 20 ml to pass through. This is the temperature at which wax crystals begin to cause blockage of filters.

16. Flash Point

This has no bearing on performance but is important largely from the point of view of safety in handling the fuel and minimum values are usually specified in the specification.
The flash point of High Speed Diesel is stipulated as min. 35°C and thus it falls under the category of class 'B' of petroleum products. While other diesel fuels have flash point of min. 66°C and hence fall in the category of class 'C' of petroleum products.

EURO III/BHARAT STAGE III EMISSION NORMS COMPLAINT-
SPECIFICATION FOR AUTOMOTIVE DIESEL FUEL

Sl. No.	Characteristics	Requirements	Test Method [P:] of IS 1448/ISO/ASTM
(1)	(2)	(3)	(4)
i)	Acidity, inorganic	Nil	[P :2]
ii)	Acidity, total, mg of KOH/g, *Max*	To report	[P :2]
iii)	Ash, percent by mass, *Max*	0.01	[P:4]/ISO 6245
iv)	Carbon residue (Ramsbottom) on 10 percent residue[1], percent by mass, *Max*	0.30	[P:8]/ISO 10370
v)	Cetane number, *Min*	51[3])	[P:9]/ISO 5165
vi)	Cetane index, *Min*	46[3])	D 4737/ISO 4264
vii)	Pour point[4], *Max*		[P:10]/D 5949 or D 5950 or D 5985
a) Winter		3ºC	
b) Summer		15ºC	
viii)	Copper strip corrosion for 3 hr at 100ºC	Not worse than No.1	[P:15]/ISO 2160
ix)	Distillation, percent v/v, recovered at 360ºC, *Min*	95	[P:18]/ISO 3405
x)		Flash Point* :	
a)	Abel, ºC, *Min*	35	[P:20]
b)	Pensky Martens closed cups[5], ºC *Min*	66	[P:21]
xi)	Kinematic viscosity cSt, at 40ºC	2.0 to 4.5	[P:25]/ISO 3104
xii)	Sediment, percent by mass, *Max*	-	[P:30]
xiii)	Total contamination, mg/kg. *Max*	24	EN 12662
xiv)	Density at 15ºC[6], kg/m3	820-845	[P:16] or [P:32][7])/D4052/ISO 3675 or ISO 12185
xv)	Total sulphur[8], mg/kg, *Max*	350	IP 336 or D 4294[9]) ISO 14596 or ISO 8754 /[P:83]/D 2785/D 5433/D 2622/D 3120
xvi)	Water content percent *(v/v)*	-	[P:40]/ISO 3733/ISO6296
Water content, mg/kg, *Max*	200		ISO 12937
xvii)	Cold Filter Plugging Point		[P:110]/D 6371

a)	Cold Filter Plugging Point (CFPP)[4], *Max*		[P:110]/D 6371	
b)	Winter		6ºC	
	Summer		18ºC	
xviii)	Oxidation stability, g/m3, *Max*	25		ISO 12205 or ASTM D 2274
xix)	Polycyclic Aromatic Hydrocarbon (PAH) percent by mass, *Max*	11		IP 391 or EN 12916
xx)	Lubricity corrected wear scar diameter (wsd 1.4) at 60ºC, microns, *Max*	460		ISO 12156-1
xxi)	Oxygen content[11], percent by mass, *Max*	0.6		Annex B

HSD (Before Adding Fuel stick):

S.No.	TEST/CL.REF.	RESULTS
1.	Kinematic Viscosity at 38°C,	4.9 eSt
2.	Inorganic Acidity	N.T
3.	Ash, wt %	N.T
4.	Flash Point (Abel's).°C	38°C
5.	Water content, vol %	0.06%
6.	Pour Point,	7°C
7.	Density at 15°C, kg/m3	841 kg/m3
8.	Sediments, wt %	0.9%
9.	Total Sulphur, wt%	0.37%
10.	Acidity, Total mg.of KOH/gm	0.35 mg of KOH/gm
11.	Gross calorific value, cal/gm	9832 cal/gm
12	Total Contamination. Mg/kg	26
13	Cold Filter Plugging Point	8°C
14	Cetane Index	43
15	Copper Strip Corrosion at 100 Deg C/3 hrs	Code No.1

HSD (After Adding Fuel Stick):

S.No.	TEST/CL.REF.	RESULTS
1.	Kinematic Viscosity at 38°C,	5.4 eSt
2.	Inorganic Acidity	N.T.
3.	Ash, wt %	N.T.
4.	Flash Point (Abel's).°C	42°C
5.	Water content, vol %	0.01%
6.	Pour Point,	0.2°C
7.	Density at 15°C, kg/m3	831 kg/m3
8.	Sediments, wt %	0.01%
9.	Total Sulphur, wt%	0.03%
10.	Acidity, Total mg.of KOH/gm	0.11 mg of KOH/gm
11.	Gross calorific value, cal/gm	10242 cal/gm
12	Total Contamination. Mg/kg	11
13	Cold Filter Plugging Point	0.2°C
14	Cetane Index	46
15	Copper Strip Corrosion at 100 Deg C/3 hrs	Code No.1

Conclusion

1. Addition of Fuel Stick reduces the levels of Sulphur Dioxide and Oxides of Nitrogen in exhaust gas emissions in diesel run engines by 62.12% & 32.03 % respectively.

2. Addition of Fuel Stick in High Speed Diesel (HSD), reduces or shortens the ignition delay, the engine runs smoother and improves the performance of the engine.

3. Addition of Fuel Stick to High Speed Diesel improves the Cetane Number of the fuel.

4. Fuel Stick doped High Speed Diesel leaves minimum Carbon residue thus indicating that there is proper or near enough complete burning of diesel fuel in the engine.

5. Addition of Fuel Stick reduces the Sulphur content in the diesel oil and this automatically helps in extending the engine life.

6. Fuel Stick helps to restore engine health.

7. Fuel Stick helps engine run cleaner which again leads o extension of engine life.

8. In all tests conducted by us, it was observed that Fuel Stick doped diesel remains within the specifications laid down by the BIS Standards thus does not harm the engine. In fact, Fuel Stick helps improve the quality of diesel.

9. Basically, with the improved quality of fuel and proper air fuel ratio, there is almost complete combustion i.e. is less un-burnt fuel which leads to less pollution and less corrosion in the engine resulting from no un-burnt fuel in the engine (which is corrosive).

10. Operating a diesel engine with fuel having lower than recommended Cetane Number can result in rough operation, low power output, excessive Carbon deposits in the system, hard starting etc.

    This can be avoided by applying Fuel Stick to the diesel that automatically increases the Cetane Number and provides smooth operation of the engine (less Noise/Vibration), low exhaust emissions and less wear and tear of the engine.