

Diesel Fuel Quality Control of Titas Gas Field (TGF), Bangladesh

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Abstract

Keywords:

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ASTM,
BST,
ERL,
Cetane number.

Petroleum derived products have an important role in different sectors of Bangladesh and so their quality should be measured and controlled carefully to get higher performance of engine. Physico-chemical characteristics of High Speed Diesel (HSD) collected from Titas gas field of Bangladesh have been determined using standard procedures set by American Society of Testing and Materials (ASTM) and Institute of Petroleum (IP). These results have been compared with the standards specifications of BSTI, ERL, European, Indian and Pakistan to assess the quality. Sometimes additives and essential chemicals are added to the final product to enrich its quality or reduce its utilization abatements. The quality of Titas HSD is almost identical to the BSTI and ERL specifications but the quality of these products is low in some cases as compared to the European, Indian and Pakistan standard specifications. It is proposed that amendment of some parameters of BSTI and ERL should be carried out to sustain the fuel quality. To enrich the diesel fuel quality cetane number, flash point, kinematic viscosity and water content values set by BSTI and ERL should be modified according to European, IS and PSI specifications. The characteristics of produced diesel are close to BSTI and ERL standard except cetane number (42.2), Kinematic viscosity (1.68 cSt) and flash point (37.78°C).

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1. Introduction

Diesel, also known as petrodiesel, is a complex mixture of hydrocarbons. Its exact composition depends on the source of crude oil/condensate from which it is produced, distillation process and the design of refinery used. Diesel fuel oil is particularly composed of saturated hydrocarbons (paraffins), unsaturated (olefins) and aromatic chains that contain from 10 to 19 carbon atoms and boil at approximately 180–370° C [1]. It consists of

fractions, which distil between kerosene and lubricating oil distillates [2]. Titas gas field is the largest gas field and the second highest producer in Bangladesh which produces daily on an average 390 bbls of condensate. This condensate has been fractionated through two fractionation plants having capacity of 1000 BBLD of this field and produced Motor Spirit (MS) and High Speed Diesel (HSD). Diesel is produced about 80% of total condensate within the boiling range of 260-610 °F. Quality of

petroleum products and HSD are generally determined by measuring various physico-chemical parameters to ensure appropriate burning in the engine. The properties are specific gravity, kinematic viscosity, cetane number, distillation range, copper corrosion, sulphur and ash contents, flash point, pour point etc. [3]. Diesel fuel oils having higher cetane numbers have enormous benefits including reduced exhaust emissions and engine noise improved cold starting and engine durability [4]. Iso-octane is the standard for the internal combustion engine and n-hexadecane (cetane) is the standard for the diesel engine reference to the quality measurement [5]. Eastern Refinery Limited (ERL) plays an important role in supplying petroleum product around 40% of the country's demand and maintains stability in the market of petroleum product of the country. It produces 16 products from these crude oils. The units of Eastern Refinery include the major process units i.e. Crude distillation unit, Catalytic reforming unit, Asphaltic bitumen plant, Long Residue Vis-breaking unit and Mild hydrocracking unit. Among them, Crude Distillation Unit (CDU) is the most energy intensive unit [6]. Bangladesh Standards and Testing Institution (BSTI) is the only National Standards body of Bangladesh playing an important role in developing and promoting industrial Standardization. BSTI is responsible for the quality control of the products which are ensured as per specific national standards made by the technical committees formed by BSTI. The European standard specification EN: 509 describe the physical properties that all automotive diesel fuel must meet. Indian standard IS: 1460 in 1974 describes the requirement for the physico-chemical properties of diesel fuel. Pakistan's Standard Institution (PSI) also sets the standards for important physicochemical properties of HSD. The

quality parameters of HSD according to the ERL and BSTI specifications should improve its standards for HSD as compared to the European, Pakistani and Indian standard specifications. Diesel fuel produced from Titas gas field has quality parameters almost similar to the BSTI and ERL but the overall quality does not meet the requirements set by European, Indian and Pakistani specifications. Diesel fuel quality can be improved either by better processing or with the use of additives. Better processed diesel or additive treated diesel contributes to improve the fuel performance, reduce harmful emissions and gives smoothness and longer life of the engine. Detergents and dispersant, cleanliness additive, cetane improver, combustion modifier and multifunctional additives are the major groups of additives [7].

2. Experimental procedures

2.1. Materials and Methods

Properties of petroleum product i.e. diesel fuel are determined by standard methods. Institute of Petroleum (IP) and American Society for testing and materials (ASTM) are the two such important organizations those standardizes test methods and issues specifications which are widely followed in worldwide. Each property has individual apparatus, procedures and specifications. Cetane number of the diesel fraction is determined through diesel fuel analyzer (D 976). Sulfur content and diesel index is determined by (IP 63) and (IP 21) respectively. Pour point and Aniline point of diesel is determined by ASTM D-97 and ASTM D-611 respectively. Other properties such as specific gravity (D 1298), viscosity (D 445), flash point (D 93), carbon residue (D 189-65), copper strip corrosion (D 130), water content (D-95), ash content (D 482-63), etc

are also determined by standard methods. These properties of diesel have to determine by standard method those are further useful for quality control measures of petrol. Distillation process is carried out by ASTM D – 86.

2.2. Experimental test

Standard specification of HSD properties set by ERL and BSTI are used to measure the quality of HSD. European, Indian and Pakistan standard specifications are tabulated to compare with the properties of diesel sample.

Diesel fuel of Titas Gas Field (TGF) comprises of the carbon fractions from C₉ to C₁₈ having the

boiling ranges from 260-610° F. Petroleum diesel, also called petrodiesel, or fossil diesel is the most common type of diesel fuel. It is produced from the fractional distillation of crude oil between 200°C (392°F) and 350°C (662°F) at atmospheric pressure, resulting in a mixture of carbon chains that typically contain between 8 and 21 carbon atoms per molecule [8]. Petroleum-derived diesel is composed of about 75% saturated hydrocarbons and 25% aromatic hydrocarbons. In case of Titas gas field, diesel is produced about 80% of total condensate within the boiling range of 260-610 °F.

Table 1: Standard specification of HSD properties set by ERL and BSTI

TESTS	METHODS	ERL Standard (March, 2002)	BSTI Standard (June, 2009) BDS 347:1999
Specific gravity, 60/60° F	ASTM D- 1298	Min. 0.820 Max. 0.870	-
Colour ASTM	ASTM D- 1500	Max. 3.0	-
Flash point, °C	ASTM D- 93	Min. 32	32
Water content, %	ASTM D- 95	Max. 0.10	0.10
Kinematic viscosity, cSt 100.4° F	ASTM D- 445	Less than 9.0	9.0
Pour Point, °C	ASTM D - 97	Max. 45	9 for winter 15 for summer
Aniline Point, °C	ASTM D - 611	46.0	-
Diesel index	IP - 21	45.0	-
Sulfer content, mass %	ASTM D- 1551	Max. 1.0	-
Copper strip corrosion for 3 hours at 100° C	ASTM D- 130	Max. No. 1	-
Cetane Number	ASTM D - 976	45	45

Table 2: Standard specification of HSD properties set by EN:509, IS: 1460-1974 and PSI specifications

Property	EN:509	IS: 1460-1974	PSI Specifications
Density at 15°C	820-845	-	-
Sulphur content,	350 mg/kg	0.05 weight %	1.0 weight %
Flash point max. °C	Above 55	38	54
Pour point max. °C		6	6
Water content max.	200 mg/kg	0.05 %	0.05 %
Cetane number, min.	51	42	-
Copper strip corrosion at 100 °C	1	1	1
Carbon residue max. weight %	0.30	0.2	0.2
Kinematic viscosity at 40°C, cSt		2.0-7.5	1.5-6.5

Ash content max. weight %	0.01	0.01	0.2
Distillation 90% recovery max. (°C)		366	365

3. Results and discussion

3.1. Cetane Number

The principal measure of diesel fuel quality is its cetane number which directly affects both ignition and operation with load. Cetane number is actually a measure of a fuel's ignition delay. This is the time period between the start of injection and start of combustion of the fuel. Fuel with a high cetane number has a short ignition delay and starts to burn soon after it is injected in an engine [9]. The optical method for determining cetane number is ASTM test D- 976. As shown in Fig. 1 the cetane number of Titas HSD is 42.2 which is identical to IS limit but lower than ERL standard (45) and much lower than EN limit (51). In a particular diesel engine, higher cetane fuels will have shorter ignition delay periods than lower cetane fuels. A higher cetane number indicates that the fuel ignites more readily when sprayed into hot compressed air. If diesel fuel derived from any crude oil/condensate does not meet the specification given by BSTI and ERL, cetane improvers should be added to modify combustion in the engine. Most cetane improvers contain alkyl nitrates which break down readily to provide additional oxygen for better combustion.

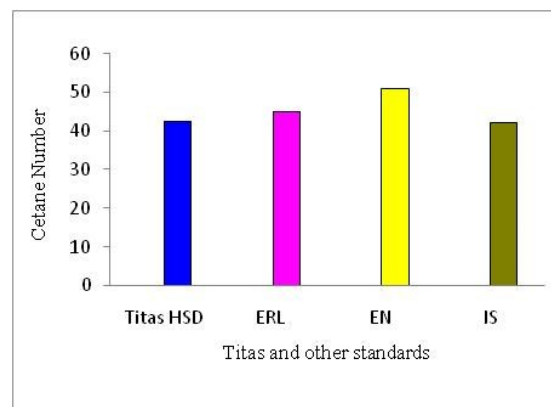


Fig. 1: Cetane number of Titas HSD and other standards.

3.2. Viscosity

Viscosity is the internal resistance of a liquid to flow, high viscosity means low flow rate of fluids from one part of the engine to the other. The kinematic viscosity is the ratio of the dynamic viscosity (μ) to the density of the fluid (ρ). Fuels with high viscosity tend to form larger droplets on injection which can cause poor fuel atomization during the spray, increases the engine deposits, needs more energy to pump the fuel and wears fuel pump elements and injectors. Viscosity and specific gravity are directly related to each other. High viscosity means the fuel is thick and does not flow easily. Highly viscous liquids burn slowly because they have low concentration of lighter components and produce more smoke [10]. Fuel with the too high or too low viscosity can cause engine or fuel system damage. Low viscosity fuel may not provide adequate lubrication to plungers, barrels and injectors, and its use should be evaluated carefully. The viscosity of the fuel affects

atomization and fuel delivery rate. From the Fig. 2, it has shown that the kinematic viscosity of analyzed HSD is 1.68 cSt but ERL and BSTI limit is 9.0 cSt at 38°C. Whereas IS and PSI standardizes the viscosity value as 2.0-7.5 and 1.5-6.5 respectively. The maximum limit of kinematic viscosity i.e. 9 cSt is too high to use in engine. Fuels with viscosities over 5.5 centistokes at 40°C are limited to use and may require pre-heating for injection. So ERL and BSTI should modify the value of kinematic viscosity and minimize the rate.

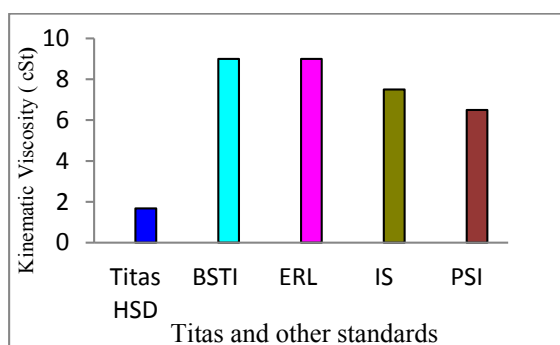


Fig. 2: Kinematic viscosity of Titas HSD and other standards.

3.3. Diesel index

Diesel index is an indication of the ignition quality of a diesel fuel. This is generally determined by the calculation from cetane number but can also be evaluated from the specific gravity and the aniline point of the sample. Higher the diesel index better is the ignition quality of diesel fuel.

$$\text{Diesel Index} = \frac{\text{Cetane number} - 10}{0.72}$$

As the cetane number of diesel fuel is empirically dependant on each other so if anyone is specified correctly another parameter will be instinctively specified. Analyzed HSD has diesel index value as

45 which is identical to ERL and BSTI. Hence the ignition quality of this diesel fuel is very good.

3.4. Flash points

Flash point is a parameter associated to the presence of highly volatile and flammable material and shows the precautionary measures to be taken during handling, transport, storage and product use. In addition, this parameter may be used to detect contamination of fuel samples with non-volatile or non-flammable materials [1]. Usually a diesel flash point is higher which make it safer than petrol and imperfect for spark-ignition engines. As shown in Fig. 3, the value of flash point of analyzed HSD is 37.78°C which is higher than that of the ERL and BSTI standard limits. In Fig. 3, the values set by BSTI and ERL are same as 32°C because ERL follows the standards set by BSTI as it is the only one national standard body of Bangladesh and hence the values of various parameters are almost similar. A sample of diesel is suitable for use when the flash point value is above 38 °C [1]. IS gives the specification for flash point as 38°C. The Pakistan and European HSD standard limits for flash point are 54°C and 55°C those are better than Indian and Bangladeshi HSD standard limit for flash point. The higher the flash point, the safer the fuel is. Hence the value of flash point set by ERL and BSTI should be increased.

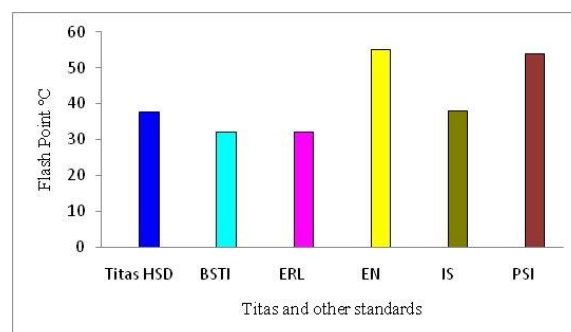


Fig. 3: Flash point of Titas HSD and other standards.

3.5. Water content

High water content in diesel fuel results in the corrosion of injector nozzle and pump, bacteria and fungi growth and fuel filter plugging with materials resulting from corrosion or microbial growth. So the water content should be kept as lower as possible. Titas HSD contains no water i.e. water content is zero in the sample. According to ERL and BSTI, the water content is specified as 0.10%. But according to IS and PSI standard the value is 0.05%. To get high efficiency of engine and corrosion less operation the water content should be minimized upto 0.05%.

3.6. Copper strip corrosion and others

Copper strip corrosion of all the analyzed HSD samples is according to all the standard limits indicating all the samples as neutral. There is no sulphur content in the HSD sample which indicates that it is environmental friendly fuel. The sulphur contents produce bad smell and produce noxious SOx gases. Hence Titas HSD is better than that of Indian, European and Pakistan HSD. Specific gravity of analyzed HSD is 0.8240 which is also identical to ERL standards. Aniline Point (46°C) of HSD also shows similarities with ERL specification.

Table 1: Standard specification of HSD properties set by ERL and BSTI.

Name of the analysis	Method	Titas HSD	BSTI Standard (June 2009) BDS 347:1999	ERL Standard (March, 2002)	EN: 509	IS: 1460-1974	PSI Specifications
Specific gravity, 60/60° F	ASTM D- 1298	0.8240	-	Min. 0.820 Max. 0.870	-	-	-
Flash point, °C	ASTM D- 93	37.78	32	32	Above 55	38	54
Water content, %	ASTM D- 95	-	0.10	0.10	200 mg/kg	0.05	0.05
Kinematic viscosity, cSt 100.4° F	ASTM D- 445	1.68	9.0	Less than 9.0	-	2.0-7.5	1.5-6.5
Pour Point, °C	ASTM D – 97	-	9 for winter 15 for summer	Max. 45	-	6	6
Aniline Point, °C	ASTM D – 611	46.0	-	46	-	-	-
Diesel index	IP – 21	45.0	45	45	-	-	-
Cetane no.	ASTM D - 976	42.4	-	45	51	42	-
Sulphur content, mass %	IP – 63	-	1.0	1.0	350mg/kg	0.05	1.0
Copper strip corrosion for 3 hours at 100° C	ASTM D- 130	1b	No worse than no.1	No. 1	1	1	1

4. Conclusions

This paper is a pragmatic study where the main intension was to analyze the specifications and standards of petroleum product e.g. diesel given by ERL and BSTI and find out the parameters those should be modified. The following conclusions can be drawn from this research:

- The result shows that all the physicochemical properties of analyzed HSD are very identical to the ERL and BSTI standards except cetane number (42.2), kinematic viscosity (1.68 cSt) and flash point (37.78°C).

ii. The cetane number of Titas HSD (42.2) is lower than the limit of diesel according to ERL standard (45) whereas according to EN and IS specification, cetane number of diesel fuel is 51 and 42 respectively.

iii. It is concluded that the cetane number value should be modified and increased because the diesel fuel with high cetane index ignites more readily and enhance the performance of engine.

iv. The study also found that the Titas HSD has kinematic viscosity of 1.68 cSt which is lower than the limit specified by ERL and BSTI both as 9.0 cSt at 38°C. But IS and PSI standardizes the viscosity value as 2.0-7.5 and 1.5-6.5 respectively.

v. As highly viscous liquids burn slowly and produce more smoke, ERL and BSTI should modify the value of kinematic viscosity and minimize the rate.

vi. The value of flash point of analyzed HSD is 37.78°C which is much higher than the value sets by ERL and BSTI as 32°C. On the contrary, IS gives the specification as 38°C, EN and PSI set the flash value as 55°C and 54°C respectively.

vii. To get high efficiency of engine and corrosion less operation the water content of diesel fuel set by ERL and BSTI should also be minimized upto 0.05%.

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