

Effect of Free Water and Rust on Flash Point of Diesel

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Abstract: Diesel is used as a fuel in many of the engines in commercial and industrial scale. Distractions encountered during the auto-ignition due to presence of water and rust in the engine or in the fuel are studied by measuring Flash point. There is increase in flash points due to presence of water, which shows free water drops are not good to present in diesel. Also this study helps to judge the quality of fuel from the bottom of the tank which is mostly having water drops and rust (solids).

Keywords: Auto Ignition, Combustible Fuel, Flash point, Filtration.

I. Introduction

Diesel fuel is liquid fuel used in diesel engines, whose fuel ignition takes place, without any spark, as a result of compression of the inlet air mixture and then injection of fuel. (Glow plugs, grid heaters and heater blocks help achieve high temperatures for combustion during engine startup in cold weather.) Diesel engines have found broad use as a result of higher thermodynamic efficiency and thus fuel efficiency. This is particularly noted where diesel engines are run at part-load; as their air supply is not throttled as in a petrol engine, their efficiency still remains very high. The most common type of diesel fuel is a specific fractional distillate of petroleum fuel oil, but alternatives that are not derived from petroleum, such as biodiesel, biomass to liquid (BTL) or gas to liquid (GTL) diesel, are increasingly being developed and adopted. To distinguish these types, petroleum-derived diesel is increasingly called petrodiesel. [1] Ultra-low-sulfur diesel (ULSD) is a standard for defining diesel fuel with substantially lowered sulfur contents. As of 2016, almost all of the petroleum-based diesel fuel available in UK, Europe and North America is of a ULSD type. In the UK, diesel fuel for on-road use is commonly abbreviated DERV, standing for diesel-engined road vehicle, which carries a tax premium over equivalent fuel for non-road use [2].

1.1 Petroleum diesel

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 8 to 21 carbon atoms per molecule.

1.2 Uses

Unlike gasoline and liquefied petroleum gas engines, diesel engines do not use high-voltage spark ignition (spark plugs). An engine running on diesel, compresses the air inside the cylinder to high pressures and temperatures (compression ratios from 14:1 to 18:1 are common in current diesel engines); the engine generally injects the diesel fuel directly into the cylinder, starting a few degrees before top dead center (TDC) and continuing during the combustion event. The high temperatures inside the cylinder cause the diesel fuel to react with the oxygen in the mix (burn or oxidize), heating and expanding the burning mixture to convert the thermal/pressure difference into mechanical work. Engines have glow plugs and grid heaters to help start the engine by preheating the cylinders to a minimum operating temperature. Diesel engines are lean burn engines, [3] burning the fuel in more air than is needed for the chemical reaction. Thus they use less fuel than rich burn spark ignition engines which use a stoichiometric air-fuel ratio (just enough air to react with the fuel). As Professor Harvey of the University of Toronto notes, "due to the absence of throttling [constant amount of air admitted, per unit fuel, with no user-determined variation], and the high compression ratio and lean fuel mixture, diesel engines are substantially more efficient than spark-ignited engines", generally; Harvey cites the side-by-side comparisons of Schipper et al. and the estimates of >20% lower fuel use and (given differences in

energy content between fuel types) >15% lower energy use.[4] Gas turbine and some other types of internal combustion engines, and external combustion engine, both can also be designed to take diesel fuel.

1.3 Flash Point

The flash point is the lowest temperature at which vapours of a volatile material will ignite, when given an ignition source. The flash point may sometimes be confused with the autoignition temperature, which is the temperature at which the vapor ignites spontaneously without an ignition source. The fire point is the lowest temperature at which the vapor will keep burning after being ignited and the ignition source removed. The fire point is higher than the flash point, because at the flash point the vapor may be reliably expected to cease burning when the ignition source is removed. [5] Neither flash point nor fire point depends directly on the ignition source temperature, but it may be understood that ignition source temperature will be considerably higher than either the flash or fire point. The flash point is a descriptive characteristic that is used to distinguish between flammable liquids, such as petrol, and combustible liquids, such as diesel. It is also used to characterize the fire hazards of liquids. Depending on the standard used, liquids which have a flash point less than either 37.8 or 60.5 °C (100.0 or 140.9 °F) are called flammable — whereas liquids having a flash point above that temperature are called combustible.

1.3.1 Mechanism

All liquids have a specific vapor pressure, which is a function of that liquids temperature and is subject to Boyle's Law. As temperature increases, vapor pressure increases. As vapor pressure increases, the concentration of vapor of a flammable or combustible liquid in the air increases. Hence, temperature determines the concentration of vapor of the flammable liquid in the air. A certain concentration of a flammable or combustible vapor is necessary to sustain combustion in air, the lower flammable limit, and that concentration is different and is specific to each flammable or combustible liquid. The flash point is the lowest temperature at which there will be enough flammable vapor to induce ignition when an ignition source is applied.

1.3.2 Measurement

There are two basic types of flash point measurement: open cup and closed cup. [6] In open cup devices, the sample is contained in an open cup which is heated and, at intervals, a flame brought over the surface. The measured flash point will actually vary with the height of the flame above the liquid surface and, at sufficient height, the measured flash point temperature will coincide with the fire point. The best known example is the Cleveland open cup (COC) [7]. There are two types of closed cup testers: non-equilibrium, such as Pensky-Martens, where the vapours above the liquid are not in temperature equilibrium with the liquid, and equilibria, such as Small Scale (commonly known as Setaflash), where the vapours are deemed to be in temperature equilibrium with the liquid. In both these types, the cups are sealed with a lid through which the ignition source can be introduced. Closed cup testers normally give lower values for the flash point than open cup (typically 5–10 °C or 9–18 °F lower) and are a better approximation to the temperature at which the vapour pressure reaches the lower flammable limit. The flash point is an empirical measurement rather than a fundamental physical parameter. The measured value will vary with equipment and test protocol variations, including temperature ramp rate (in automated testers), time allowed for the sample to equilibrate, sample volume and whether the sample is stirred. Methods for determining the flash point of a liquid are specified in many standards. For example, testing by the Pensky-Martens closed cup method is detailed in ASTM D93, IP34, ISO 2719, DIN 51758, JIS K2265 and AFNOR M07-019. Determination of flash point by the Small Scale closed cup method is detailed in ASTM D3828 and D3278, EN ISO 3679 and 3680, and IP 523 and 524. CEN/TR 15138 Guide to Flash Point Testing and ISO TR 29662 Guidance for Flash Point Testing cover the key aspects of flash point testing.

II. Equipment Used



Fig.1 Pensky-Martens Apparatus

In the Pensky–Martens closed-cup flash-point test, a brass test cup is filled with a test specimen and fitted with a cover. The sample is heated and stirred at specified rates depending on the material that is being

tested. An ignition source is directed into the cup at regular intervals with simultaneous interruption of stirring until a flash that spreads throughout the inside of the cup is seen. The corresponding temperature is its flash point. Pensky–Martens closed cup is sealed with a lid through which the ignition source can be introduced periodically. The vapour above the liquid is assumed to be in reasonable equilibrium with the liquid. Closed cup testers give lower values for the flashpoint than open-cup testers (typically 5–10 K) and are a better approximation to the temperature at which the vapour pressure reaches the "lower flammable limit" (LFL).

III. Experimental

Water and Rust are added to diesel in order to check the variations happened for flash point value.

3.1 Addition of Water

- Water content Test: Using Karl Fischer Titrator
- Method of Mixing

Diesel and Water is mixed well and shaken for 10 mins in closed container and is kept for 24hrs for saturation at 28 °C.

Table.1 Amount of water added

S.No	Diesel added (g)	Amount of Water added (g)	Amount of Water measured (ppm)
1	52	1.56	30050
2	52	1.04	20015
3	52	0.52	9993
4	52	0.26	5080
5	52	0	180

3.2 Addition of Rust

Mainly 3 ways samples were prepared:

- Sample with sediments: collected from bottom of the tank from Fuel Station; 1. added directly 2. after filtration.
- Another Sample stored in iron container for 20 days
- Rust added externally to the Diesel at different proportions

Table.2 Rust added at different proportions

S.No	Diesel added (g)	Amount of Rust added (g)
1	52	1.56
2	52	1.04
3	52	.52
4	52	.26
5	52	0

IV. Procedure

1. Fill the test cup with the test portion to the level indicated by the filling mark. Place the lid on the test cup and put it in the heating chamber. Ensure that the locating or locking device is properly engaged and insert the thermometer. Light the test flame and adjust to a diameter of to 4mm or switch on the alternative ignition source. Light the heater flame or switch on the electric heater and supply heat at such a rate that the temperature of the test portion as indicated by the thermometer increases at to, and maintain this heating rate throughout the test. Stir the test portion at a rate of to, stirring in a downward direction.
2. When the test portion is expected to have a flash point of or below, make the first application of the ignition source when the temperature of the test portion is below the expected flash point, and thereafter at temperature intervals. Cease stirring and apply the ignition source by operating the mechanism on the cover, which controls the shutter and ignition source, so that the source is lowered into the vapour space of the test cup in, left in its lowered position for, and quickly raised to its high position.
3. When testing a material of unknown flash point, conduct a preliminary test at a suitable starting temperature. Make the first ignition-source application at above the starting temperature and follow the procedure given in 2.
4. Record, as the observed flash point, the temperature of the test portion read on the thermometer at the time when the ignition-source application causes a distinct flash in the interior of the test cup. Do not confuse the true flash point with the bluish halo that sometimes surrounds the ignition source at applications preceding the actual flash point.
5. When the temperature at which the flash point is observed is less than, or greater than, from the temperature of the first application of the ignition source, the result is not valid. Repeat the test using a fresh test portion, adjusting the temperature of the first application of the ignition source until a valid determination is obtained, that is where the flash point is to above the temperature of the first application of the ignition source.

V. Observation

Table.3 Water in diesel

S.No	Diesel added (g)	Amount of Water measured (ppm)	Flash point Observed (°C)
1	52	30050	72
2	52	20015	66
3	52	9993	65
4	52	5080	62
5	52	180	60

Table.4 Rust in diesel

S.No	Diesel added(g)	Amount of Rust added(g)	Flash point Observed (°C)
1	52	1.56	59
2	52	1.04	59
3	52	.52	60
4	52	.26	60
5	52	0	61

- Sample taken from the bottom of the fuel station without filtration: 61°C
- Sample taken from the bottom of the fuel station with filtration (3.8% solids separated, 195 ppm water): 61°C
- Sample stored in Iron container for 20 days: 62 °C

VI. Results

Standard test method IS 1448 P21 was carefully followed to test all the samples. Presence of free water in Diesel fuel shows increase in flash point and which is very significant parameter to justify the combustion efficiency. In real life situation diesel fuel may contain water drops or Engine may encounter water drops. Increase in flash point indicates spending more fuel in startup of the engine followed by fall in efficiency. All the three samples with the presence of solids and rust is almost showing same flash point as pure diesel sample.

VII. Conclusion

Presence of free water in the fuel will cause combustion or initial ignition problems. Since most of the Diesel engines are auto ignited, initial presence of water may cause trouble in self ignition. This study helps to find the flash point in the presence of water and which can be related with auto ignition temperatures. Presence of rust or solid content in a small quantity does not really affect the flash point but it may clog the mechanical parts inside the engine.

Reference

- [1]. Traders and importers now use the term, as well as academic journals for example ACS publications (See 2006 article on comparing Petrodiesel emissions with other types of fuel). The term is common in blogs and informal wiki sites, and is used several times in this article itself.
- [2]. "The UK oil industry over the past 100 years" (PDF). Department of Trade and Industry, UK Government. March 2007. p.5. Archived from the original (PDF) on 4 March 2011.
- [3]. See How Stuff Works [1] for an excellent explanation
- [4]. L. D. Danny Harvey, 2010, "Energy and the New Reality 1: Energy Efficiency and the Demand for Energy Services," London: Routledge-Earthscan, ISBN 1-84407-912-0, p. 264, 267; see [2], accessed 28 September 2014.
- [5]. Sea Transport of Petroleum, Jansen and Hayes, Ainsley, South Shields 1938.
- [6]. NFPA 30: Flammable and Combustible Liquids Code, 2012 Edition Retrieved January 4, 2014.
- [7]. Jansen and Hyams. Fundamentals of Petroleum Fluids. ISBN 1-5467-427-2 pp 62-78.
- [8]. "Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester", ASTM.org.