iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** X **Month of publication:** October 2017

DOI: http://doi.org/10.22214/ijraset.2017.10304

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue X, October 2017- Available at www.ijraset.com

Effect of Rust & Free Water on Flash Point of Diesel and Petrol Samples

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Abstract: ***Petrol and Diesel are commercially used fuels in engines. Few distract actions are encountered while auto-ignition due to presence of water and rust in the engine, as the fuel are properties are determined and understood by analysing flash point of petrol and diesel samples. Since increase in flash points are due to presence of water, which shows free water drops is found to exhibit negative effects present in tested diesel and petrol. Present study helps to determine/analyse the quality of fuel from the bottom of the tank which is predominantly has water drops and rust particles.***
Keywords: Rust, Diesel, Petrol, Ignition, Combustion Fuel, Flash point, Filtration

I. INTRODUCTION

Petrol, Diesel are considered to be the most effectively used fuel for commercial purposes used in petrol and diesel engines respectively, where fuel ignition happens without any spark for diesel engine whereas for petrol little spark is required due to the compression and reaction taking place with injected fuel in the presence of air. Petrol and Diesel fuel are obtained by fractional distillation of crude oil, whereas alternatives to petroleum and diesel fuels such as bioethanol and biodiesel, biomass to liquid (BTL) or gas to liquid (GTL) diesel are produced to meet the increasing demand for these fuels. Among Diesel engines. Petrol engines have found broad use as a result of higher thermodynamic efficiency. Moreover, it has to be noted that usage of diesel engines run at part-load as their air supply is not throttled as in a petrol engine, their efficiency still remains very high compared to petrol engines. To differentiate both, petroleum-derived diesel is increasingly called biodiesel [1]. In Australia diesel fuel is also known as distillate and in Indonesia, it is known as Solar, a trademarked name by the local oil company Pertamina [3]. Ultra-low-sulfur diesel (ULSD) is a standard for defining diesel fuel with substantially lowered sulphur contents. Since mid of 2015, every petroleum-based diesel fuel being commercialized in Europe and America is of a ULSD type. In the UK, diesel fuel for on-road use is commonly abbreviated DERV, standing for diesel-engine road vehicle, which carries a tax premium over equivalent fuel for non-road use [2].

A. Derivatives of Crude Oil

Petroleum diesel fuel is the most commercial type of fuel used which is mainly produced by fractional distillation of crude oil between 200 °C - 350 °C by maintaining atmospheric pressure which indeed will result in mixture of carbon atoms distributed with 8 and 21 per molecule.

B. 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 centre (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, i.e., to move the piston. 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. They thus use less fuel than rich burn spark ignition engines which use a stoichiometric air-fuel ratio (just enough air to react with the fuel). In the absence of throttling and high compression ratio, diesel engines are considered to be more efficient than spark ignited engines. Harvey cites the side-by-side comparisons of Schipper et al. where it is estimated to be >20% lower fuel use and (given differences in energy content between fuel types) >15% lower energy use [3]. Gas turbine and some other types of internal combustion engines, and external combustion engine, both can also be designed to take diesel fuel.

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C. 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 auto ignition temperature, which is the temperature at which the vapour ignites spontaneously without an ignition source. The fire point is the lowest temperature at which the vapour 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 [1]. 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) *Mechanism:* The use of the flash point to identify hazardousness of particular fuel is most essential. The tendency on the part of petroleum distillers to leave as much as possible of the commercially worthless gasoline in the kerosene in order to sell more product. All liquids have a specific vapour pressure, which is a function of that liquid's temperature and is subject to Boyle's Law. As temperature increases, vapour pressure increases. As vapour pressure increases, the concentration of vapour of a flammable or combustible liquid in the air increases. Hence, temperature determines the concentration of vapour of the flammable liquid in the air. At particular a concentration, the vapour produced due to combustion is necessary to initiate combustion in air, so that the lower flammable limit is achieved and the concentration reaches to flammable or combustible liquid. The flash point is the lowest temperature at which there will be enough flammable vapour to induce ignition when an ignition source is applied. This adulteration of petrol and diesel with highly volatile gasoline caused numerous fires and explosions in storage tanks and oil lamps. Legal measures were instituted to curb the danger, and test methods were prescribed and minimum flash points set.Flash points are measured by heating a liquid to specific temperatures under controlled conditions and then applying a flame. The test is done in either an “open cup” or a “closed cup” apparatus, or in both, in order to mimic the conditions of storage and the workplace.
2) *Measurement:*Generally, two basic types of flash point measurements are performed such as open cup and closed cup [3]. The oil sample placed in an open cup which is heated at a regular interval of time so that a flame brought over the surface and the method is known as open cup. 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 and successive example is the Cleveland open cup (COC) [2].There are two types of closed cup testers: non-equilibria, such as Pensky-Martens, where the vapours above the liquid are not in temperature equilibrium with the liquid, and equilibria, such as Small Scale, 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 (5 – 9 °C or 10 – 16 °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. Determination of flash point by the Small Scale closed cup method is detailed in ASTM D3828 and D3278.

II. EQUIPMENT

Fig. 1 Pensky – Marten Flash Point Apparatus

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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 are considered to be better approximation to the temperature at which the vapour pressure reaches the lower flammable limit (LFL).

III.MATERIALS

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

A. Addition of Water

1) Water content Test: Using Karl Fischer Titrate

2) 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. I Amount of water added to oil samples

S. No	Petrol sample added (g)	Amount of H_2O added (g)	Amount of H_2O measured (ppm)	Diesel sample added (g)	Amount of H_2O added (g)	Amount of H_2O measured (ppm)
1	35	1.50	29565	35	1.50	31234
2	35	1.25	22578	35	1.25	26798
3	35	1.0	8848	35	1.0	9563
4	35	0.75	5385	35	0.75	6183
5	35	0.50	2568	35	0.50	2839

B. Addition of Rust

Mainly 3 ways samples are checked:

1) Sample with sediments; collected from bottom of the tank from Fuel Station; added directly or after filtration.

2) Another Sample stored in iron container for 20 days

3) Sample added at different proportions

TABLE. II Addition of Rust at different ranges

S. No	Petrol added (g)	Amount of Rust added (g)	Diesel added (g)	Amount of Rust added (g)
1	35	1.5	35	1.5
2	35	1.0	35	1.0
3	35	0.5	35	0.5
4	35	0.25	35	0.25
5	35	0	35	0

IV.METHODOLOGY

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. 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

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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.

When the test portion is expected to have a flash point of above, make the first application of the ignition source when the temperature of the test portion is below the expected flash point, and thereafter at temperatures which are a multiple of. 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. 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 above steps.

Record the observed flash point temperature of the test portion read on the thermometer at the time when the ignition-source was applied which 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. 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 source of ignition.

V. OBSERVATIONS

TABLE. III Presence of water in petrol and diesel samples

S. No	Petrol added (g)	Amount of Water added (g)	Amount of Water measured (ppm)	Flash point Observed (°C)	Diesel added (g)	Amount of Water added (g)	Amount of Water measured (ppm)	Flash point Observed (°C)
1	35	1.5	29565	65	35	1.5	31234	74
2	35	1.0	22578	63	35	1.0	26798	68
3	35	0.5	8848	61	35	0.5	9563	66
4	35	0.25	5385	58	35	0.25	6183	64
5	35	0	2568	54	35	0	2839	62

TABLE. IV Presence of rust in petrol and diesel samples

S. No	Petrol added (g)	Amount of Rust added (g)	Flash point Observed (°C)	Diesel added (g)	Amount of Rust added (g)	Flash point Observed (°C)
1	35	1.5	58	35	1.5	60
2	35	1.0	59	35	1.0	62
3	35	0.5	60	35	0.5	63
4	35	0.25	62	35	0.25	64
5	35	0	62	35	0	63

1) Sample taken from the bottom of the fuel station without filtration: 60°C
2) Above sample with filtration (3.5% solids separated, 198 ppm water): 60°C
3) Sample stored in Iron container for 15 days: 55 °C

VI. RESULTS

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Standard test method IS 1448 P21 protocol was had been followed to test samples in the presence of free water as well as inducing rust artificially to both petrol and diesel samples so that to identify flash point to analyze the efficiencies of the fuels which were subjected to combustion. The tested samples in the presence of rust (solid particles) exhibit almost similar flash point as that of pure petrol/diesel samples.

VII. CONCLUSIONS

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 oint 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.

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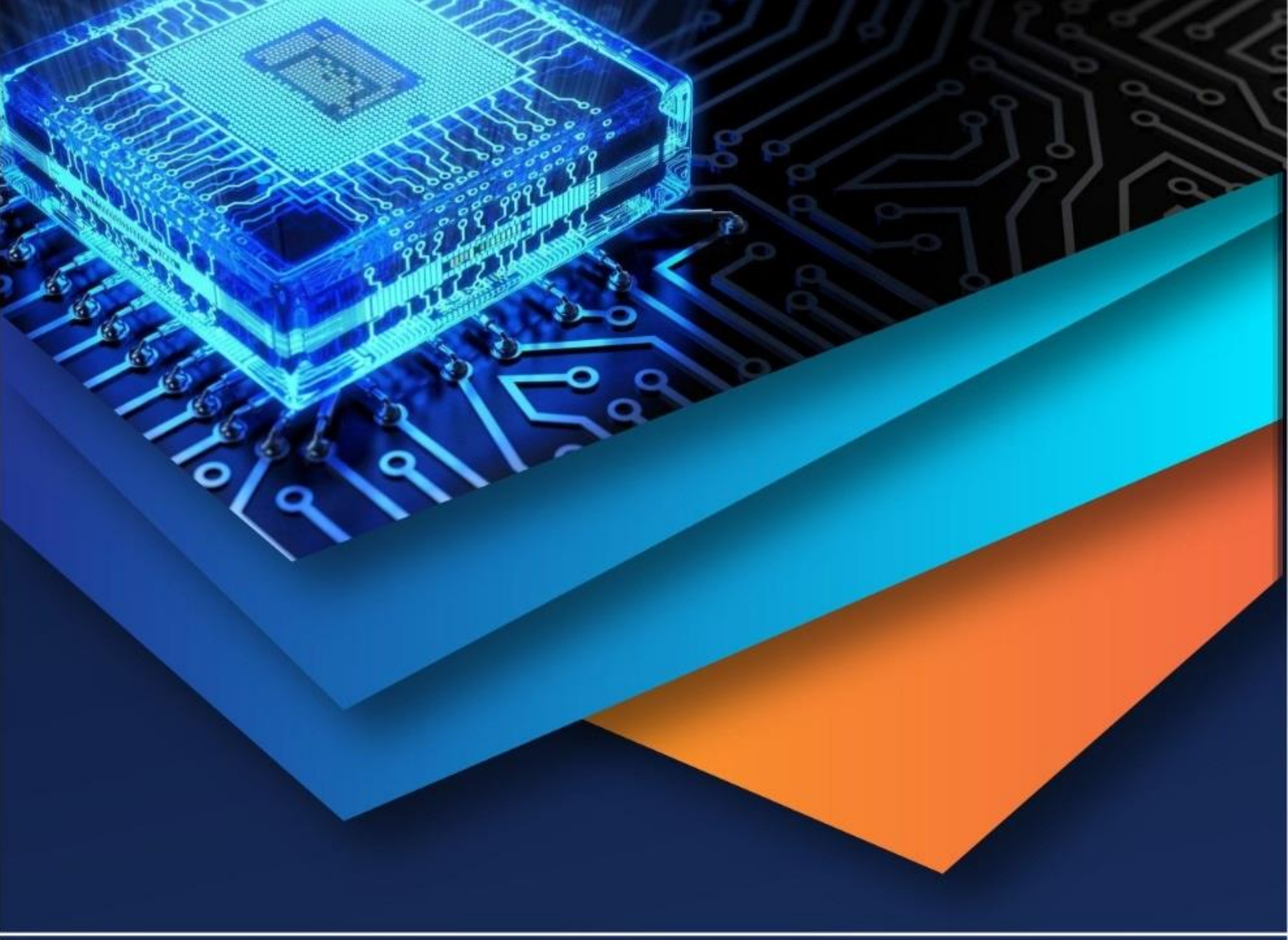

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