

STUDY AND TESTING OF PETROLIUM DIESEL AND BIO DIESEL



Engineering

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ABSTRACT

In this paper, the general morphology of oil plants and seeds and availability of oils are explained. Combustion parameters such as density, viscosity, flash point, fire point, cetane number and calorific value of all types of chosen oils and their blends with diesel oil are presented in this paper. Effect of blending vegetable oil with diesel on viscosity is discussed. Effect of heating on viscosity of oils and their blends with diesel is studied in this paper. Testing and comparison of all combustion parameters of petroleum diesel, bio diesel from edible vegetable oil and bio diesel from non edible vegetable oil is discussed.

INTRODUCTION

Many recent research programs focus on the development of concepts such as renewable resources, sustainable development, green energy, eco-friendly process, etc. in the transportation sector. Known petroleum reserves are estimated to become depleted in less than 50 years at the present rate of consumption. In developed countries, there is a growing trend towards employing modern technologies and efficient bio energy conversion using a range of biofuels, which are becoming competitive with fossil fuels cost-wise.

The term biofuel is used to refer to liquid or gaseous fuels for the transport sector that are predominantly produced from biomass. Biomass appears to be an attractive feedstock for three main reasons. First, it is a renewable resource that could be sustainably developed in the future. Second, it appears to have formidably positive environmental properties resulting in no net releases of carbon dioxide and very low sulfur content. Third it appears to have significant economic potential, provided that fossil fuel prices increase in the future (Cadenas and Cabezudo, 1998). Lignocellulosic bio-methanol have such low emissions because the carbon content of the alcohol is primarily derived from carbon that was sequestered in the growing of the bio-feedstock and is only being re-released into the atmosphere (Difiglio, 1997).

Diesel engines have been widely used as power of engineering machinery, automobile, and shipping equipment for its drivability and thermal efficiency. At the same time, diesel engine are major contributors of various types of air Pollutant emissions such as carbon monoxide (CO), oxides of nitrogen (NOx), soot and other harmful compounds. With the increasing concern of environmental protection and more stringent government regulation on exhaust emissions, reductions in engine emissions become a major research task in engine development. Simultaneous reduction in nitric oxides emissions and particulate matter is quite difficult due to the soot/NOx trade off and is often accompanied by fuel consumption penalties. Thus, improvement of fuel properties is also essential for the suppression of diesel pollutant emissions along with the optimization of combustion related design factors and exhaust after treatment equipment.

Crude vegetable oils which come from both edible and non-edible oils such as rapeseed, palm or soybean, Mahua, Pongamia, Karanja, Jatropha and Neem oil can be used straight in diesel engines as a fuel but the major relevant difficulties are because of their high viscosity, low volatility and poor cold flow properties. Vegetable oil when used as a fuel cause nozzle choking and cok-

ing, gumming, deposition on the piston top, sticking of piston rings and contamination of the lube oil. Corrosion, chocking of injection system and poor atomization due to its high viscosity is a major problem. Apart from these, starting the engine may become difficult especially in cold weather. Because of poor atomization and low volatility of fuel, smoke and particulate emissions are relatively more.

Production process of biodiesel is shown in figure 1.

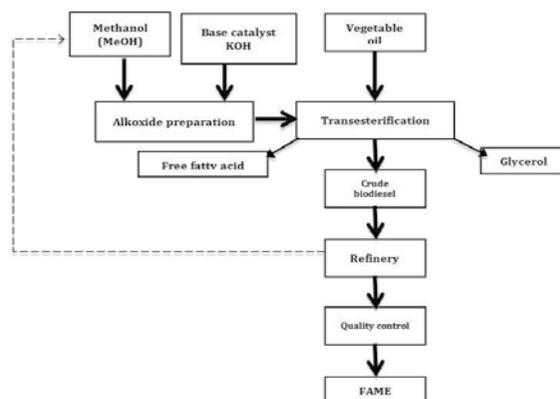


Figure 1: Production Process of Biodiesel

Problems with the use of vegetable oil as fuel for internal combustion engines are as shown below :

- Higher viscosity
- Lower Heating Value.
- Carbon particle deposition at tip of fuel injector.

To improve performance of engine using vegetable oil it is essential to reduce its viscosity. Transesterification is a very successful technique to reduce viscosity of vegetable oil.

There are number of oils available in market which may be processed to make biodiesel are shown in Table 1

TABLE – 1

Sr.no	Edible Oil	Non Edible Oil
1	Palm Oil.	Neem
2	Soya Oil.	Karanja

3	Cottonseed oil.	Kusum
4	Rapeseed Oil.	Pilu
5	Mustard Oil.	Ratanjot (Jetropha)
6	Corn oil.	Jaoba
7	Sunflower Oil.	Bhikal
8	-----	Wild Walnut
9	-----	Undi
10	-----	Thumba

Properties of Bio diesel:-

A detailed understanding of the various properties of bio-diesel is essential to study their implications in engine use, storage, handling and safety.

Density/ Specific Gravity:

Bio-diesel is slightly heavier than conventional diesel fuel (specific gravity 0.88 compared to 0.84 for diesel fuel). This allows use of splash blending by adding bio-diesel on top of diesel fuel for making bio-diesel blends. Bio-diesel should always be blended at top of diesel fuel. If bio-diesel is first put at the bottom and then diesel fuel is added, it will not mix.

Cetane Number:

Cetane number of a diesel engine fuel is indicative of its ignition characteristics. Higher the cetane number better it is in its ignition properties. Cetane number affects a number of engine performance parameters like combustion, stability, drive ability, white smoke, noise and emissions of CO and HC. Bio-diesel has higher cetane number than conventional diesel fuel. This results in higher combustion efficiency and smoother combustion. Cetane number resists knocking.

Viscosity:

Viscosity is resistance to flow of fluid, proper viscosity of fuel of diesel engine leads to better atomization of fuel. Bio diesel is always having trouble with viscosity. The viscosity of any bio diesel is higher than the conventional diesel. To reduce that transesterification method is used. Higher viscosity affects the diesel injector and it changes the characteristics of droplets size and spray of fuel.

Distillation characteristics:

The distillation characteristics of bio-diesel are quite different from that of diesel fuel. Bio-diesel does not contain any highly volatile components, the fuel evaporates only at higher temperature. Boiling point of bio-diesel generally range between 330°C to 357°C. The limit of 360°C is specified mainly to ensure that high boiling point components are not present in bio-diesel as contaminants.

Flash point:

Flash point of a fuel is defined as the temperature at which it will ignite when exposed to a flame or spark. The flashpoint of bio-diesel is higher than the petroleum based diesel fuel. Flashpoint of bio-diesel blends is dependent on the flashpoint of the base diesel fuel used, and increase with percentage of bio-diesel in the blend. Thus in storage, bio-diesel and its blends are safer than conventional diesel. The flashpoint of bio-diesel is around 500°C, but it can reduce drastically if the alcohol used in manufacture of bio-diesel is not removed properly. Residual alcohol in the bio-diesel reduces its flashpoint drastically and is harmful to fuel pump, seals, elastomers etc. It also reduces the combustion quality.

Cold Filter Plugging Point (CFPP):

At low operating temperature fuel may thicken and not flow properly affecting the performance of fuel lines, fuel pumps and injectors. Cold filter plugging point of bio-diesel rejects its cold weather performance. It defines the fuels limit of filter ability. Bio-diesel thicken at low temperatures so need cold flow improver additives to have acceptable CFPP.

Pour Point:

The pour point of a liquid is the lowest temperature at which it becomes semi solid and loses its flow characteristics. The pour point of bio diesel is nearer to diesel.

Cloud Point :

Cloud point is the temperature at which a cloud or haze of crystals appear in the fuel under test conditions and thus becomes important for low temperature operations. Bio- diesel generally has higher cloud point than diesel fuel.

Stability:

Bio-diesel age more quickly than fossil diesel fuel due to the chemical structure of fatty acids and methyl esters present in bio-diesel. Typically there are up to 14 types of fatty acid methyl esters in the bio-diesel. The individual proportion of presence of these esters in the fuel affects the final properties of bio-diesel. Saturated fatty acid methyl esters increase cloud point, cetane number and improve stability whereas more polyunsaturated reduce cloud point, cetane number and stability. There are three types of stability criteria, which need to

be studied:

Oxidation stability : more related to engine operation as engine components attain high temperatures during operation.

Storage stability

Thermal stability

Oxidation Stability:

Poor oxidation stability can cause fuel thickening, formation of gums and sediments, which, in turn, can cause filter clogging and injector fouling. Iodine number indicates the tendency of a fuel to be unstable as it measures the presence of C=C bonds that are prone to oxidation.

Storage Stability:

Very little data is available on the long-term storage stability of bio-diesel. Effect of presence of water, sediments, and additives on storage stability need to be investigated more. Based on the data available so far it is recommended that bio-diesel and its blends should not be stored in a storage tank or vehicle tank for more than 6 months. There is need to develop appropriate test methods for oxidation and storage stability of bio-diesel.

Free and Total glycerol:

The degree of conversion completeness of the vegetable oil is indicated by the amount of free and total glycerol present in the bio-diesel. If the actual number is higher than the specified values, engine fouling, filter-clogging etc can occur. Manufacturing process controls are necessary to ensure low free and total glycerol. Free glycerol if present can build up at the bottom of the storage and vehicle fuel tank.

Ester content:

France (96.5%), Italy (98) and Sweden (98) specify a minimum ester content whereas Austrian and ASTM Standards do not specify any limit.

Alkaline matter (Na, K) :

Alkaline matter is controlled mainly to ensure that the catalysts used in the esterification process are properly removed.

Total contamination:

Left over impurities at the time of manufacture (such as free proteins) may form solid particles and clog the fuel lines. Filtration and washing treatments at manufacturing level need to be robust.

Sulfur content:

Bio-diesel generally contain less than 15ppm sulfur.

Lubricity:

Wear due to excessive friction resulting in shortened life of diesel fuel pumps and injectors, has some times ascribed to lack of lubricity in the fuel. Numerous premature breakdown and in some cases, catastrophic failures, have occurred failures.

Acid number/Neutralization number:

resultant high acid number can cause damage to injector and also result in deposits in fuel system and affect life of pumps and filters. Sodium hydro peroxide and sulfuric acids are highly corrosive and can cause serious, many times permanent, injuries.

In following para. Properties of biodiesel as recommended as per ASTM and Indian standards is shown:

Properties of bio diesel as per ASTM and Indian standards

Table 2: US and Indian standards for bio diesel

Standard For Biodiesel	ASTM D -6751	IS 15607 :2005
Density	Not mentioned	860 -900Kg/m ³
Ester content	Not mentioned	96.5%
Flash point (Closed cup)	130°C	120°C
Water and sediment	0.050%by vol,max	500 mg/Kg max
Kinematic viscosity at 40°C	1.9-6.0 mm ² /s	2.5-6.0 mm ² /s
Oxidation stability	Not mentioned	6 hours min at 110°C
Rams bottom Carbon residue,% mass	0.10	-
Sulfated Ash	0.020% by mass max	-
Sulfur	0.05% by mass max	-
Copper strip corrosion 3 hrs, 50°C	No. 3 max	Class 1
Cetane number	47 min	51 min
Carbon Residue	0.05% by mass max	-
Acid Number .mgKOH/g	0.80max	0.50max
Methanol or Ethanol	Not mentioned	0.2% m/m max
Free Glycerin	0.020% mass	0.020% mass
Total glycerin(free and Unconverted glycerides Combined)	0.24% by mass max	0.25% by mass max
Group I Metal (Na +K)	5 mg/Kg max	5 mg/Kg max
Group II metal (ca + Mg)	Not mentioned	5 mg/Kg max
Phosphorus content	0.001 max % mass	10 mg/Kg max
distillation	90% at 360°C	Not mentioned

Experimental Work :

Palm oil and Karanja oil were transesterified separately using NaOH as catalyst and methanol to form biodiesel.The fuel properties like viscosity, density, flash point, fire point and calorific value of the transesterified product(biodiesel) are compared with accepted biodiesel standards i.e Indian biodiesel standards.

Table No. 3

Property	Karanja Biodiesel	Palm Biodiesel	Diesel
Kinematic viscosity at 40°C(cSt)	5.2	4.8	3.0
Density @15°C (Kg/m ³)	860	876	833
Ash content (% m/m)	0.015	0.018	0.006
Carbon Residue (% m/m)	0.04	0.02	0.12
Sulfur content (mg/Kg)	28	15	30
Flash point(°C)	174°C	130°C	74°C
Fire point (°C)	230°C	171°C	120°C
Cloud point (°C)	6°C	13°C	-16°C
Pour point(°C)	15°C	17°C	
Calorific value (KJ/Kg)	37000	38600	42850
Water content (mg/Kg)	380	411	105
Total contamination (mg/Kg)	10	14	10
Copper corrosion 3 hour at 50°C	Class I	Class I	Class I
Ceten no	41.7	62.8	49.0
Acid Value (KOH/g)	0.81	0.30	0.35
Methanol percent by mass (% m/m)	0.11	0.16	--
Ethanol 3] Percent by mass mass (% m/m)	Not detected	Not detected	--
Ester content Percent by mass mass (% m/m)	96.9	97.2	---

Free Glycerol percent by mass mass (% m/m)	0.01	0.02	---
Total Glycerol percent by mass (% m/m)	0.17	0.14	--
Phosphorus (mg/Kg)	6	4	--
Sodium and Potassium(mg/Kg)	0.08	0.10	---
Calcium and magnesium(mg/Kg)	0.17	0.19	---
Iodine value (g/100g)	91	45	--
Oxidation stability at 110°C	6Hr	9Hr	22mg/m ³
Lubricity, WSD 60°C	---	---	350
Distillation (250°C) (% v/v)	---	---	52
Distillation(95%)	---	---	322°C
Fatty Acid Methyl Ester	---	---	Not detected

Conclusion:-

As heating values of biodiesel is less almost by 10 % it may be assumed that there will be more fuel consumption using biodiesel. This results into increased break specific fuel consumption.

High flash point temperature of this biodiesel shows it is safe to transport and store it.

As biodiesel contains oxygen it can provide better combustion due to presence of oxygen .But higher oxygen content may result into more NO_x formation due to higher reaction temperature.

Biodiesel having lower viscosity may provide improved injection and atomization.

Cetane no. of esters is greater, which improves combustion and thus emissions like Hydrocarbons, Carbon Monoxides may reduce resulting into reduction in cancer risk to human beings and reduced potential of green house gases.

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