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Impact of cold flow properties of biodiesel on engine performance

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ABSTRACT

In the view of rapid depletion of fossil fuels and rise in price of crude oil, there is emergent focus and need to search for alternative fuels. As we know that there is huge demand of diesel for transportation sector, captive power generation, agricultural sector and industrial sector, to accommodate those demands biodiesel is being viewed as a substitute for diesel. Biodiesel is an engine fuel that is prepared by chemical reaction of fatty acids and alcohol, which usually means combining vegetable oil with methanol in the presence of a catalyst (usually sodium hydroxide). But before using biodiesel as a substitute for engine fuel, there are two major problems associated, first one is "cold flow property of biodiesel" and second one is termed as "stability of biodiesel". In this paper our main focus will be on cold flow property of biodiesel and its impact on engine performance. Some of the cold flow properties such as cloud point, pour point and cold filter plugging point are responsible for solidification of fuel causing blockage in fuel lines filters which further leads to fuel starvation in engine operation during starting operation. This paper also provides several remedial measures for improving the cold flow properties of biodiesel.

Contents

1. Introduction

Today the world is facing the crises of exhaustion of fossil fuels due to rapid industrialization, which further leads to environmental degradation. The extraction and consumption of fossil fuels

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in abundance have led to reduction in petroleum reserves. These finite reserves are highly concentrated to certain regions of the world. Therefore, countries which are not having these resources are facing foreign exchange crisis, mainly due to the import of crude petroleum oil. Hence it is necessary to look for other alternative fuels, which can be produced from renewable energy sources like solar, hydro, wind and bio fuel [1]. The vegetable oils are used as alternative fuels from around one hundred years, when the inventor of the diesel engine Rudolph Diesel first tested peanut oil in his compression-ignition engine. In 1970, scientists discovered that the viscosity of vegetable oils could be reduced by a simple chemical process and that it could be used as diesel fuel in modern engine. Considerable efforts have been made to develop a vegetable oil derivative that resembles the properties and performance of the hydrocarbon-based diesel fuels. In Indian perspective the non edible oil can be used as an alternative source of fuel [2]. We know that among non edible plant sources like *neem, mahua, Sal, Jatropha, Pongamia*, major source of biodiesel are *Jatropha* and *Pongamia*, since other plants have medicinal and other uses.

But in the use of non edible oil as fuel there are some major problems associated with them. First one is oxidation stability of biodiesel and other is cold flow properties of biodiesel. It was reported that the combustion characteristics of biodiesel are similar to diesel and the blends were found to be having shorter ignition delay, higher ignition temperature, higher ignition pressure and peak heat release [3].

2. Biodiesel

Biodiesel is defined as the mono alkyl esters of vegetable oils or animal fats. The biggest advantage of biodiesel over gasoline and petroleum diesel is its environmental friendly nature. Biodiesel burns similar to petroleum diesel as it contains regulated pollutants. On the other hand, biodiesel probably has better efficiency than gasoline [2].

Table 1 shows the ASTM and IS standard for diesel and biodiesel. The high kinematic viscosity of biodiesel is the main problem in engine operation because high kinematic viscosity leads to poor combustion and results in carbon deposit and smoke emission [3].

3. Problem of using biodiesel

There are two main problems associated with the use of biodiesel as an alternative of diesel. These are poor cold flow properties and there stability. The various researchers have tried to find out the solution of these problems. Jain and Sharma [5] states that biodiesel consists of long chain fatty acid esters derived from feed stocks such as vegetable oils, animal fats and used frying oil, etc. These products may contain more or less unsaturated fatty acids which are prone to oxidation, accelerated by exposure to air during storage and at high temperature and may yield polymerized compounds. Auto oxidation of biodiesel can cause degradation of fuel quality by affecting the stability parameters. Biodiesel stability includes oxidation, storage and thermal stability. Oxidation instability can led to the formation of oxidation products like aldehydes, alcohols, shorter chain carboxylic acids, insoluble, gum and sediment in the biodiesel.

Thermal instability is concerned with the increased rate of oxidation at higher temperature which in turn, increases the weight of oil and fat due to the formation of insolubles. Storage stability is the ability of liquid fuel to resist change in its physical and chemical characteristics brought about by its interaction with its environment and may be affected by interaction with contaminants, light, factors causing sediment formation, changes in colour and other changes that reduce the clarity of the fuel. These fuel instabilities give rise to formation of undesirable substances in biodiesel and its blends beyond acceptable quantities as per specifications and when such fuel is used in engine, it impairs the engine performance due to fuel filter plugging, injector fouling, deposit formation in engine combustion chamber and various components of the fuel system.

4. Cold flow properties of biodiesel

Crystallization of the saturated fatty acid during winters causes fuel starvation and operability problems as solidified material clogs to fuel lines and filters. With decreasing temperature more solid is formed and material approaches the pour point which is the lowest temperature at which it will cease to flow. It has been well established that the presence of higher amount of saturated components increases the cloud point and pour point of biodiesel utilization of additives that enhance the impact of crystal morphology and blending with a fuel like kerosene which causes freezing point depression [6].

There is no single best way to assess low temperature performance, and the existing fuel standards (both U.S. and European) do not include explicit specifications for cold flow properties for either conventional diesel or biodiesel. However, the fuel provider is generally required to give an indication of the cold flow properties by reporting the cloud point (CP) of the fuel. A number of other laboratory tests are commonly used to define low temperature properties of biodiesel, poor cold flow properties

Table 1
Specification of diesel and biodiesel fuels [4].

Fuel property Fuel standard	Bio diesel IS 15607	Bio diesel ASTM D 6751	Diesel IS 1460	Diesel ASTM D 975
Lower heating value, Btu/gal	116090	118170	19300	129050
Kinematic viscosity, @ 40 °C	8	4.0–6.0	2.5–4.5	1.3–4.1
Specific gravity, kg/L @ 60 °F	0.85	0.88	0.95	0.85
Density, lb/gal @ 15 °C	8.60	7.328	8.20	7.079
Water and sediment (vol%)	0.005	0.05 Max	.05	0.05 Max
Carbon (wt%)	–	77	86.1	87
Hydrogen (wt%)	–	12	7.48	13
Oxygen, by dif. (wt%)	–	11	1.39	0
Sulfur (wt%)	.02	0.01–0.0024	.035	0.05 Max
Boiling point (°C)	–	315–350	250	180–340
Flash point (°C)	120	100–170	66	60–80
Cloud point (°C)	–	−3 to 12	5	−15 to 5
Pour point (°C)	−15	−15 to 10	3	−35 to −15
Cetane number	46	48–65	51	40–55