Experimental Investigation Of Diesel Engine Using Different Blends Of Mixed Pongamia-Coconut Biodiesel As Alternative Fuel

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Abstract

Diesel engines are the most efficient prime movers for transportation, agricultural machinery and industries. The rapid depletion of petroleum reserves and rising oil prices has led to the search for alternative fuels. Biodiesel is an alternative diesel fuel derived from vegetable oils and animal fats holds good promises as an eco-friendly alternative to diesel fuel. Transesterification process is the most widely used technology for producing biodiesel from vegetable oil. In the present investigation, mixed pongamia-coconut methyl ester is produced through transesterification process by considering pongamia and coconut oil in equal proportions using NaOH catalyst under lab set up. The obtained biodiesel is blended with petroleum diesel for various ratios (10%, 20%, 30%, 40% and 50%) to evaluate its fuel properties. Experimental investigations were conducted on unmodified single cylinder diesel engine using different blends of mixed biodiesel at variable loads and fixed injection pressure. The result indicates that fuel properties and engine performance are better up to biodiesel blend B20.

Keywords: Transesterification, Pongamia oil, Coconut oil, Engine Performance, sodium hydroxide.

1. Introduction

Fuels derived from renewable biological resources for use in diesel engines are known as biodiesel. Biodiesel is environmentally friendly liquid fuel similar to petrol-diesel in combustion properties. Increasing environmental concern, diminishing petroleum reserves and agriculture based economy of our country are the driving forces to promote biodiesel as an alternate fuel. Since India is net importer of vegetable oils, edible oils cannot be used for production of biodiesel. India has the potential to be a leading world producer of biodiesel, as biodiesel can be harvested and sourced from non-edible oils like Jatropha Curcas, Pongamia Pinnata, Neem (Azadirachta indica), Mahua, castor, linseed, Kusum (Schlechera trijuga), etc [1].

The first use of vegetable oil in a compression ignition engine was first demonstrated by Rudolph diesel using peanut oil in his diesel engine [2]. Later with the availability of cheap petroleum, crude oil fractions were refined to serve as 'diesel', a fuel for CI engines. During the period of World War-II, vegetable oils were again used as fuel in emergency situations when fuel availability became scarce. Nowadays, due to limited resources of fossil fuels, rising crude oil prices and the increasing concerns for environment, there has been renewed focus on vegetable oils and animal fats as an alternative to petroleum fuels [3].The use of oils from coconut, soybean, sunflower, safflower, peanut, linseed, rapeseed and palm oil amongst others have been attempted. The long term use of vegetable oils led to injector coking and the thickening of crankcase oil which resulted in piston ring sticking. Therefore, vegetable oils are not used in SI engines because of endurance issues [4].

Researchers have proved that when the vegetable oil is converted to esters of alcohols by transesterification, it becomes a potential alternate to diesel and the term biodiesel is used to represent such fuels. Biodiesel can be used in its neat form or as a blend with conventional diesel fuel in diesel engines and the use of biodiesel in diesel engines requires no hardware modification. In addition, biodiesel is a superior fuel than diesel because of lower sulphur content, higher flash point and lower aromatic content [5].

Considerable efforts have been made to develop vegetable oil derivatives that approximate the properties and performance of hydrocarbons-based diesel fuels. The problem with substituting triglycerides for diesel fuel is mostly associated with high viscosity, low volatility and polyunsaturated characters. These can be changed in at least four ways: pyrolysis, micro emulsion, dilution and transesterification [6].

2. Methodology

2.1 Transesterification process

The transesterification process is the reaction of a triglyceride (fat or oil) with an alcohol to form esters and glycerol. A triglyceride has a glycerine molecule as its base with three long chain fatty acids attached.

During the transesterification process, the triglyceride is reacted with alcohol in the presence of an acidic or basic catalyst. The alcohol reacts with the fatty acids to form the mono-alkyl ester, or biodiesel and crude glycerol. In general, methanol or ethanol is the alcohol used (methanol produces methyl esters, ethanol produces ethyl esters). The reaction between the fat or oil and the alcohol is a reversible reaction and hence alcohol must be added in excess to drive the reaction towards the right and ensure complete conversion. The products of the reaction are the biodiesel itself and glycerol. The experimental methodology of producing biodiesel is shown in Figure 1.

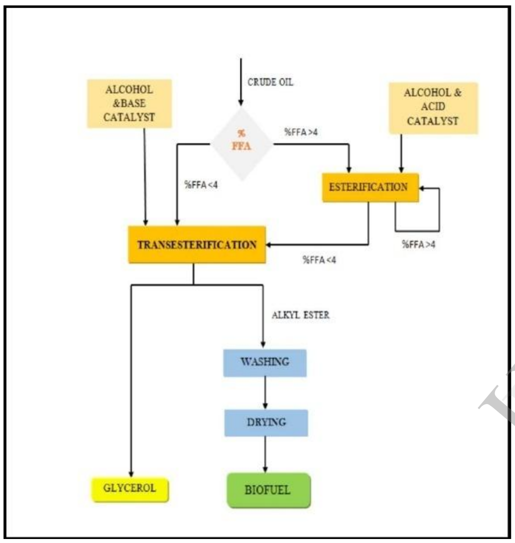

Figure 1. Biodiesel production process

2.2 Experimental set up:

The experiments were conducted on a kirloskar made four stroke single cylinder water cooled direct inject compression ignition engine without any hardware modifications. Mixed pongamia–Coconut biodiesel blends (B10, B20, B30, B40, and B50) and diesel was used to test a conventional engine. The engine was started by manual hand cranking and test is conducted for various loads with constant engine speed of 1500 RPM. Performance parameters like brake power, brake specific fuel consumption and brake thermal efficiency were evaluated. The engine specifications are given in the Table 1.

Table 1. Engine Specifications

Type	Kirloskar
Details	Single cylinder, four stroke, water cooled
Bore & Stroke	80×110 mm
Rated Power	3.75 KW at 1500 RPM
Compression Ratio	16:1to 25:1
Starting	Hand start with cranking handle

3. Results and Discussion

Table 2 shows the fuel properties of Diesel, Mixed biodiesel and its blends. Biodiesel blends of Mixed Pongamia-Coconut methyl esters with diesel on 10, 20, 30, 40, and 50% volume basis was prepared and fuel properties are measured following standard procedure. The properties of mixed biodiesel and its blends are compared with ASTM biodiesel standards as shown in Table 2.

Table 2. Fuel properties of Diesel, Mixed biodiesel and its blends

Properties	Diesel	Biodiesel Blends					B100
		B10	B20	B30	B40	B50	
Viscosity (Cst)	**3.02**	**3.201**	**3.319**	**3.409**	**3.84**	**4.02**	**4.76**
Density (Kg/m^3)	**816**	**820**	**826.7**	**839.5**	**850.8**	**856.2**	**876.4**
Flash point (°C)	**52**	**57**	**60**	**64**	**70**	**78**	**121**
Fire point (°C)	**61**	**62**	**65**	**69**	**76**	**85**	**128**
Calorific value (KJ/Kg)	**43796**	**42936**	**42701**	**42100**	**41650**	**41317**	**39251**

Figure 2. Transesterification

Figure 3. Mixed Pongamia-Coconut biodiesel blends

3.1 Specific fuel consumption:

Specific fuel consumption is a measure of the fuel efficiency of an engine. It is the rate of fuel consumption divided by the power produced.

Fig. 4 shows the variation of specific fuel consumption with load for Mixed Pongamia and Coconut biodiesel blends for a conventional engine. From Fig. 4 it is observed that mixed biodiesel blends B10 and B20 have specific fuel consumption close to diesel. It is also observed that the specific fuel consumption of all the biodiesel blends is higher than diesel at all the loads. A higher proportion of mixed oil in the blends increases the viscosity which in turn increased specific fuel consumption due to poor atomization of the fuel.

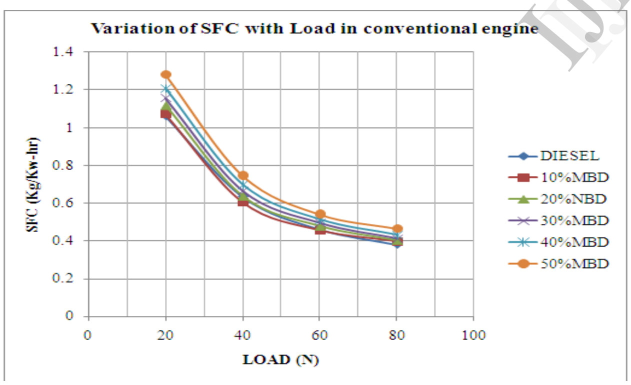

Figure 4. Variation of Specific Fuel Consumption with Load

3.2 Brake thermal efficiency:

Fig.5 shows the variation of Brake Thermal Efficiency with load for Mixed Pongamia and Coconut biodiesel blends for a conventional engine.

Brake Thermal Efficiency is defined as brake power of engine as a function of the thermal input from the fuel.

From the Fig. 5 it is also observed that blends B20 and B30 have the efficiency comparatively closer to diesel. The maximum efficiency obtained for mixed biodiesel blend is 21.18% which is almost close to the efficiency of diesel. Blend B50 shows the minimum efficiency at all the loads. The decrease in brake thermal efficiency for higher blends may be due to the lower heating value and higher viscosity of blends with a higher proportion of biodiesel.

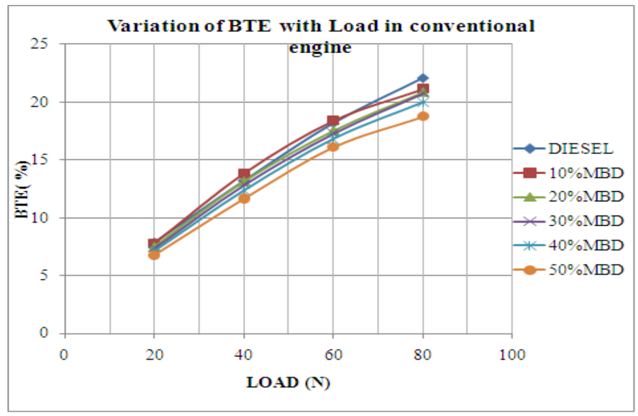

Figure 5. Variation of Brake Thermal Efficiency with Load

4. Conclusion

A single step process i.e., Transesterification is carried out for the mixed pongamia and coconut oil which contained low percentage of FFA to obtain the biodiesel. It was observed that the obtained biodiesel has very high density and viscosity which made it not possible to use in its pure form but it can be blended with diesel to obtain properties almost similar to that of diesel. The blends were prepared with biodiesel percentages of 10, 20, 30, 40 and 50 and the following conclusions were drawn from this investigation.

- Mixed Pongamia and coconut biodiesel satisfies the important fuel properties as per ASTM specification of biodiesel.
- It is observed that for the biodiesel blends of 10% and 20% the density, fire point, flash point and calorific value were very close to that of diesel, which makes them suitable for using them as an alternative for diesel.
- The mixed pongamia and coconut shows higher biodiesel yield of 72.5%.
- The mixed biodiesel blend B10 shows the higher brake thermal efficiency which is slightly less than that of diesel.
- The specific fuel consumption of mixed biodiesel blends B10 and B20 shows value closer to diesel.

Mixed pongamia and coconut biodiesel blends B10 and B20 can be used as alternative fuel in diesel engine

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