International Journal of Scientific & Engineering Research Volume 9, Issue 7, July-2018
ISSN 2229-5518

Performance Characteristics of Biodiesel Using Waste Cooking Oil

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Abstract −The use of waste cooking oil (WCO) from extended household and restaurants was considered as a suitable feedstock for biodiesel production. It also focuses to showcase the qualities of biodiesel produced from WCO compared to diesel fuel. The oil that was supposed to be disposed, at times indiscriminately was de-odoured and purified using appropriate solvents. The purified oil was characterized and used for biodiesel production. The physical and fuel properties such as density, viscosity, cloud point, pour point, cetane number etc, were determined according to ASTM standards. The properties obtained were not only comparable with that of others but also within standard limits. The emission such as CO, HC, NOx, O2 of biodiesel and BP, BSEC, BTE are compared with the diesel fuel.

Index Terms- waste cooking oil, exhaust emission, performance test.

1 Introduction

In the recent past, intensive studies on internal combustion engines has emerged with a view to obtaining higher rate of production of fuels from alternative sources. The increase in alternative fuel investigations is caused by main factors; a rapid decrease in world petroleum reserves and important environmental concerns originating from exhaust emissions. Biodiesel, a renewable fuel made by trans-esterification of vegetable oil with alcohol, is becoming more readily available for blending with conventional diesel fuel for use in transportation applications. Fossil fuels such as petroleum, coal and natural gas, which have been used to meet the energy needs of mankind, are associated with negative environmental impacts such as global warming. Similarly, the fossil fuels accumulated over series of geological activities are irreversibly consumed at a rate more than million times faster than they were formed. This has left us in a precarious position especially for petroleum products. The hike in price of petroleum and its products, both in national and international scenes is frequent for two reasons; the mounting demands and fast depletion of reserves the duo of which call for alternative source of energy. Similarly in developing countries, the price paid for petrol, diesel and petroleum products now dominates over all other expenditures and forms a major part of country's import bill Biofuel/Biodiesel made from natural oils and fats is being considered as a promising substitute for petrol and diesel.

Diesel Engine

The internal combustion engine is an engine in which the combustion of a fuel (normally a fossil fuel) occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. In an internal combustion engine, the expansion of the high temperature and high pressure gases produced by combustion apply direct force to some component of the engine. This force is transferred to crankshaft through connecting rod, transforming chemical energy into useful mechanical energy.

Diesel engines are the best for power plants today because of their high thermal efficiency, good torque characteristics and ability to cater to a wide range of applications. In India, majority of the power plants for heavy transportation, agriculture as well as industries use diesel engines and hence the consumption of diesel is almost six times higher than that of petrol. The cost of diesel is going up in an uncontrollable way and so is the cost of transportation. Costs of transportation affect the price of all commodities and in turn the economic progress of the country. A nation's development is strongly dependant on the availability of fuels for transportation, agriculture and power generation. Thus, India, like many developing countries faces the major challenge of meeting the high demand for oil. Only by using the renewable sources of fuel with clean combustion, we can reduce emissions and also the dependence on conventional petroleum sources. Therefore, there is a need to stimulate the use of renewable energy sources to increase the rate of economic growth and national development. This is particularly significant for a country like India has the more number of chicken stalls to produce bio-fuels. If the energy need of rural areas can be met by locally available fuels, then the problem of large imports of crude oil can be eased out a little. Fuels suitable for rural applications should have the capability to be used with little processing. Several alternative fuels are being considered for use in engines. The potential alternatives fuels are gaseous fuels and liquid fuels.

In the year 1892, Compression ignition engine was introduced by RUDOLFDIESEL (1858-1913) a German engineer born in Paris. Here, compression of air alone to sufficiently high temperature ignited the fuel without the help of ignition systems. Today CI engine is a very important prime mover, being used in buses, trucks, locomotives, tractors, pumping sets and other stationary industrial applications, small and medium electric generation and marine propulsion.

The importance of CI engine is due to:-

1. Its higher thermal efficiency than SI engines

2. CI engines fuels (diesel oils) being less expensive than SI engine fuels (petrol).

Furthermore, since CI engines fuels have a higher specific gravity than petrol, and since fuel is sold on volume basis (litres) and not on mass basis (kg), more kg of fuel per litre are obtained in purchasing CI engine fuels. These factors make the running of the CI engines much less than SI engine and hence make them attractive for all industrial, transport and other applications. However, in passenger cars it has not found much favour because of the main drawbacks of a CI engine in relation to SI engine i.e., heavier weight, noise and vibration, smoke and odour. Because of the utilization of higher compression ratios (12:1 to 22:1 compared to 6:1 to 11:1 of SI engine) the forces coming on the various parts of the engines are greater and therefore heavier parts are necessary. Also because of heterogeneous mixture, lean mixture (large air-fuel ratio) is used. Both result in a heavier engine. Performance tests are necessary to carry out for an engine to assess the fuel and thermal efficiencies. Further, it is also required to study the effect of different parameter on the engine performance, i.e. incomplete combustion of heterogeneous mixture, and droplet combustion. Compression ignition engines, because of their varied applications, are manufactured in a large range of sizes, speed and power inputs. The piston diameters vary from about 50mm to 900mm, speed range from 100 to 4400rpm and power output range from 2 to 40000 BHP. Performance tests of internal combustion engines are conducted since the beginning of this century and their actual design is a result of this extensive accumulation of practical knowledge. However, the understanding of the physical phenomena and the precise identification of the processes taking place inside the engine always lagged behind experimental information. Various reasons exist for this lag between theory and practice, but the main problems are due to fact that the processes are not in steady state and accurate high temperatures, the working fluid consumption changes by chemical reaction and the complexity of all geometries.

In this project we have conducted experiment in Diesel engine with diesel and different Biodiesel blends. The different proposition for Biodiesels blends of B10, B20 and B30 waste cooking oil biodiesel is used to run the engine at nearly constant speed of 1500 rpm at different loads from 2 to 10 kg, the load were increased gradually with the help of adding weights on rope drum, time taken for 10 cc of fuel consumption in different load are noted. Further the readings were used to prepare the table and plot the graph for different proposition of waste cooking oil biodiesel blends.

Table 1.1; Fuel properties of Diesel.

Property	Diesel
Chemical formula	C_3 –C_{25}
Molecular weight	˜200
Carbon	84-87
Hydrogen	13-16
Specific gravity	0.81-0.89
Density ,kg/m^3	823-844
Gross heat of combustion, MJ/kg	42.5-46.5
Cetane number	45-50
Auto ignition temperature ^{0}C	230-280
Latent heat of vaporization (1 bar, kJ/kg)	233-251
Stoichiometric air fuel ratio	14.7
Boiling temperature, ^{0}C	188-343
Freezing Point, ^{0}C	-40
Flash point, ^{0}C	73
Calorific valve (kJ/kg)	45500

1.1. The main pollutants of IC engines

1.1.1. Smoke: It is the visible product of combustion. As the outer layer of fuel droplet burns, heat is generated and transferred to the interior layers. The availability of oxygen for reaction is lesser at the interior layers. The core of the fuel droplet heated continuously but without or less oxygen is present hence due to heat hydrocarbon splits into hydrogen and carbon molecules .As hydrogen molecules are more reactive compare to carbon they will react with oxygen and left no oxygen for carbon molecules. Therefore carbon molecules fail to burn within the time span available for combustion. These unburnt carbon molecules are appeared as smoke which is major pollutant in diesel exhaust.

1.1.2. Carbon monoxide: It is a product of incomplete combustion due to insufficient time in the cycle of combustion in other word there is no proper amount of air-fuel mixture. These diesel engines always work lean side of stoichiometric thus carbon monoxide will be lesser.

1.1.3. Unburnt hydrocarbon: These due to incomplete combustion, there are mainly 2 type of mechanism for this emission

- Fuel injected in delay period
- Fuel injected when combustion is already occurring

Fuel injected during the ignition delay will mix with air to produce a wide range of equivalence ratios. Some of the fuel will have mixed rapidly to equivalence ratio lesser than lower limit combustion, some will be in equivalence, and some will be over rich mixture. The over rich mixture will not auto ignite or support propagating flame at conditions are most favourable for auto ignition. In the premixed combustion mixture, ignition occurs where the local conditions are most favourable for auto ignition unless quenched by the thermal boundary layers or rapid mixing with air, subsequent auto ignition or flame fronts propagating from the ignition sides consume the combustible mixture. It depends on the further mixing with air or lean already burnt gases within the time available before rapid expansion and cooling occurs. Of all this mechanisms over lean mixture path is believed to be most important.

1.1.4. Nitrogen oxides: The air supplied for combustion contains about 23% of oxygen. At lower temperature the nitrogen inert but at a temperature higher than 11000c, nitrogen reacts with oxygen in order to form NO_x high temperature and oxygen is required. Oxides of nitrogen occurs in the engine exhaust are the combination of nitric oxides and nitrogen dioxide. When the proper amount of oxygen is available, higher the peak combustion temperature more the nitrogen oxides are formed.

Specification of engine

SL.NO	Parameter	Specification
1.	Type	Four stroke direct injection single cylinder diesel engine.
2.	Fuel	H S diesel
3.	Rated power	5.2KW @ 1500rpm
4.	Cylinder diameter	87.5mm.
5.	Stroke length	110mm.
6.	Compression ratio	17.5:1
7.	Orifice diameter	20mm.
8.	Dynamometer arm length	185mm.

Much of the world uses a system known as the "B" factor to state the amount of biodiesel in any fuel mix.

- 100% biodiesel is referred to as **B100**,

While

- 10% biodiesel, 90% Diesel is labelled **B20.**
- 20% biodiesel, 80% Diesel is labelled **B40.**
- 30% biodiesel, 70% Diesel is labelled **B60**.

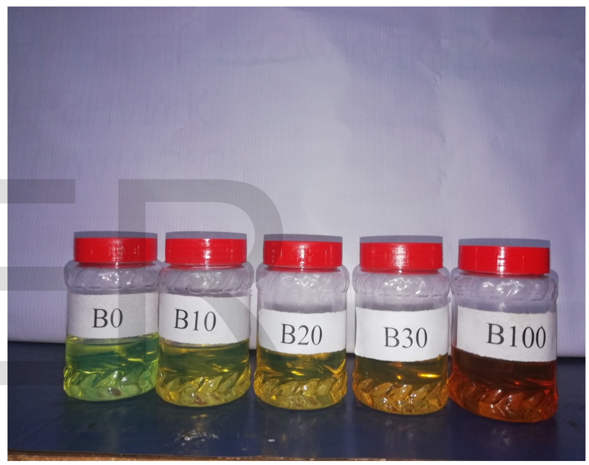

Fig 1.1: Blending of biodiesel

2 RESULTS AND DISCUSSION

2.1 Brake Thermal Efficiency (BTE)

The brake thermal efficiency is the ratio of energy in the brake power to the input fuel energy in appropriate units. Means the ratio of total energy available from engine to the total energy supplied from the engine.

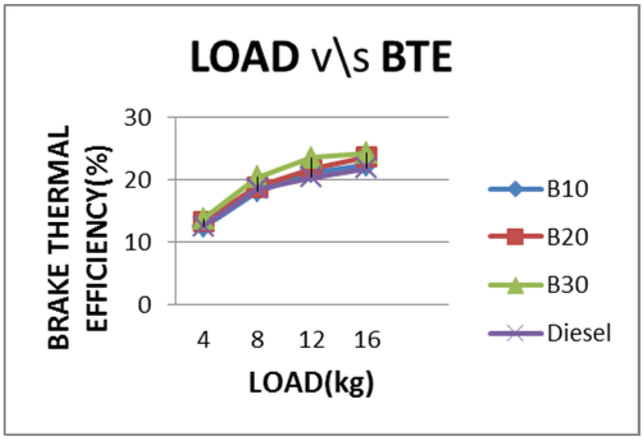

Fig.2.1: Variation of brake thermal efficiency with load for B10, B20 and B30 of waste cooking oil biodiesel.

The above figures show the variations in brake thermal efficiency is plotted against load for diesel, waste cooking oil biodiesel and its blends. It was observed that with the increase of the load, brake thermal efficiency increase in all cases. As observed from graph BTE for diesel is more than both biodiesel. That's because of the viscosity of the biodiesel is more than the diesel so the mass flow rate of the biodiesel blends is decreases, then the BTE for biodiesel is less. All waste cooking oil biodiesel blends are showing good results for Brake thermal efficiency. Especially the BTE for B20 blend of both biodiesels characteristics approaching diesel characteristic.

2.2 Fuel consumption

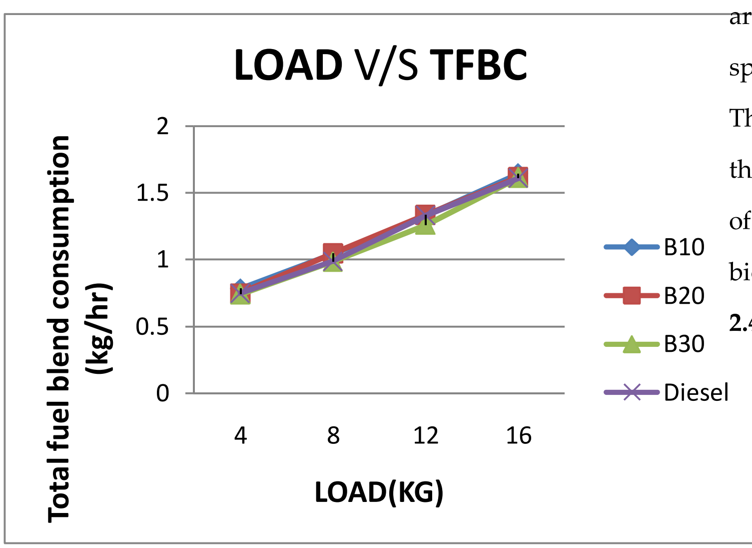

Fig. 2.2 Variation of fuel consumption with load for B10, B20 and B30 blends of waste cooking oil biodiesel.

The variation of fuel consumption with load for different blends of biodiesel and neat diesel are shown in above figures. It was observed that consumption of fuel increases with the increase of load. The diesel fuel consumption was less in all load conditions due to the high calorific value of diesel than the biodiesel blends. For B20 waste cooking oil biodiesel blend fuel consumption was slightly approaching neat diesel fuel.

2.3 Brake Specific energy Consumption

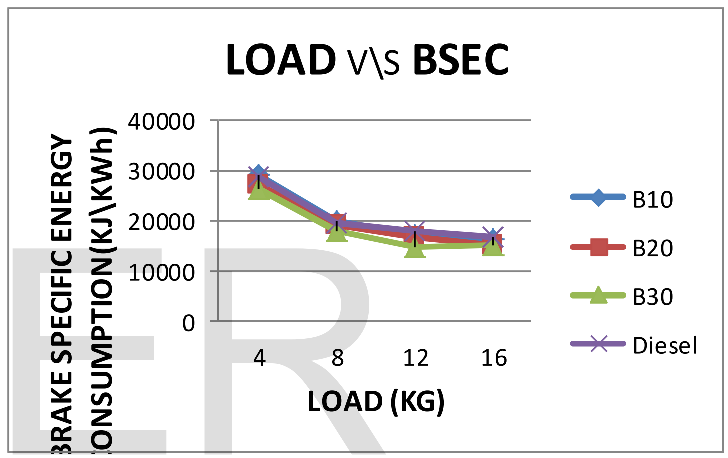

Fig.2.3 Variation of BSEC with load for B10, B20, B30 blend of biodiesels.

The variation of brake specific fuel consumption with load for different blends of waste cooking oil biodiesel and neat diesel are shown in above figures. From graph it is observed that the specific fuel consumptions decreased with the increase of load. The specific fuel consumption of biodiesel blends is higher than the neat diesel in all load conditions due to high viscosity of the biodiesel blends. The specific fuel consumption for B20 biodiesel blend is near to commercial diesel.

2.4 TOTAL ENERGY CONSUMPTION (TEC)

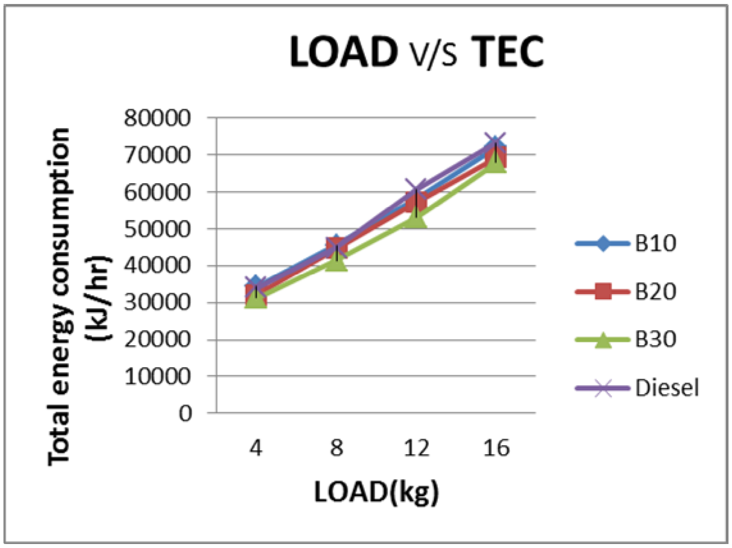

Fig.2.4 Variation of TEC with load for B10, B20, and B30 blend of biodiesels

The variation of Total energy consumption with load for different blends of waste cooking oil biodiesel and neat diesel are shown in above figures. From graph it is observed that the Total energy consumptions increase with the increase of load.

3 Conclusion

Waste cooking oil is an economical choice for biodiesel production, because of its availability and low cost. This oil has many undesirable compounds such as polymers, free fatty acid (FFA), and many other chemicals that are formed during frying, which are of major concern during the transesterification reaction. Pretreatment of the waste cooking oil to remove these undesirable chemicals is not practical. Depending on the water and FFA content of the waste cooking oil, a transesterification method should be selected. If the FFA and water contents are <1 wt % and <0.5 wt %, respectively, then an alkaline catalyst is more suitable for the ester production. If the FFA content of oil is high (>1 wt %), then an acid catalyst is a good choice. However, because of the requirement of high catalyst concentration and high molar ratio, and because of corrosion problems, these catalysts are also not recommended for the transesterification of waste cooking oil. A two-step method (an acidcatalyzed step, followed by an alkaline-catalyzed step) is not feasible, because it requires many steps, which makes the biodiesel process costly. Enzyme-catalyzed transesterification is a very good option to all chemical-catalyzed reactions; however, it must be developed for its commercialization. The catalyst-free supercritical methanol method has great potential for biodiesel production from waste cooking oil; however, the requirements of high temperature (350 °C), high pressure (45 MPa), and high molar ratio of oil to alcohol (1:42) makes the use of this process difficult on an industrial scale. It is recommended that the development of a novel solid acid catalyst that consists of large pores, a moderate to high concentration of strong acid sites, and a hydrophobic surface could be a better choice for the transesterification of waste cooking oil with high FFA. The performances of biodiesel obtained from waste cooking oil as transportation fuel or as an additive are better in all aspects, except for increased NO*x*emissions and high Conradson carbon residue (CCR).

From the following work, we get three conclusion and they are explained as follows:

1. Increasing load on engine resulted in decreasing BSFC in all cases.
2. Increasing load on engine resulted in increasing brake thermal efficiency.
3. Increasing load on engine resulted in increasing temperature in all cases.

4 Scope of Future Work

- The performance and emission characteristics of both biodiesel blends can be carried out by varying compression ratio.
- Providing preheater in the engine to heat the fuel before being injected to the engine cylinder so as to decrease the viscosity.
- Adding some additives like diethyl carbonate added to both biodiesel to increase the octane number of the fuel.

- The performance and emission characteristics of both biodiesel and its blends can be tested in multi cylinder engine.
- If preheater is provided in the engine instead of using both biodiesel blends, biodiesels can be directly used.
- For different blends, waste cooking oil biodiesel can be used to improve the performance of CI engine.

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