International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume No.2, Issue No.6, pp : 524-527 1 June 2013

Study of Performance Characteristics of Diesel Engine Fuelled with Diesel, Yellow Grease Biodiesel and its Blends

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Abstract— The feedstock used in our experiment for the production of biodiesel was Yellow Grease. The whole experiment was divided into two parts: Production and Testing. Production involves Transesterification of free fatty acids in yellow grease to form yellow grease alkyl esters. The process of testing involved calculation of the physio – chemical properties, acid value, density, kinematics viscosity and various performance characteristics. The properties obtained were similar to the standards of biodiesel set by ASTM D6751. The conclusions derived from the experiments conducted were that the break thermal efficiency with biodiesel blends was little lower than that of diesel. The break specific energy consumption for B20, B40, B60, B80 and B100 is slightly higher than neat diesel. At all loads, diesel was found to have the lowet exhaust tempearture and the temperature for the different blends showed the upward trend with increasing concentration of biodiesel in the blends.

Keywords—**Alkyl ester, *Biodiesel, Blends,* Transesterification, Performance testing, Yellow Grease.**

I. Introduction

The growth of vehicle ownership and Indian population has led to greater fuel consumption and this growth is putting a lot of stress on the available energy resources. Some of the energy resources like Coal, Crude oil and Natural gas are of main concern as they are depleting very fast. The price of vegetable oil used as feedstocks for biodiesel production is increasing day by day because of which we have to switch to some other means of producing biodiesel. The use of yellow grease as feedstock will significantly reduce the cost of Biodiesel. The review of the work done by the previous researches proves that less work has been done on usage of yellow grease as feedstock [1-10]. Our present work focuses on the production and usage of yellow grease biodiesel as a replacement of diesel in engines. The work involved production of biodiesel using yellow grease as feedstock and evaluation of performance characteristics of diesel engine using yellow grease biodiesel and its comparison with neat diesel.

II. MATERIALS AND METHODS

A. Materials

Yellow grease is typically used-frying oils from deep fryers and is also produced from rendering companies. [11]. It contains rendered animal fat such as tallow, poultry or lard. Generally yellow grease must meet the following specifications:

- Maximum FFA content should be maximum 15 percent
- Moisture, Impurities and Unsaponifiables (MIU) should be less than 2 percent
- Water content should not be more than 1 percent

The yellow grease used in our experiment satisfies all the above specification and hence it is used as a feedstock to produce biodiesel. The feedstock used in our experiment was the used cooking oil discarded by the student mess of our college. The advantage of using yellow grease was that being a waste product it was given to us for free.

B. Transesterification of Yellow Grease

Transesterification reaction also known as alcoholysis was used to produce biodiesel from yellow grease. It involved reacting vegetable oils or animal fats catalytically with short-chain aliphatic alcohols (typically methanol, ethanol or Iso-propyl) to form mixture of fatty acids alkyl esters and glycerol [12]. Potassium Hydroxide was used to catalyze the reaction and it was mixed with Methanol to produce Methoxide solution. Yellow grease was mixed with Methoxide solution and heated on a magnetic stirrer for one hour and maintained at a temperature of 60 – 65 degree Celsius.

C. Yellow Grease Biodiesel Properties

The physio – chemical properties of biodiesel were calculated on various machines and have been listed in Table 1.

Table.1 Properties of Biodiesel

Properties	Value
Acid Value	0.3658 mg KOH/gm
Density at 15 degree Celsius	0.89125g/cm3
Kinematic viscosity at 40 degree Celsius	5.326255 Centistokes
CFPP	-7 degree Celsius
Calorific Value	39.339 MJ/Kg

D. Biodiesel Testing Rig

The engine selected for testing was a DAF8 model made by Kirloskar. It is an air cooled (radial cooled), vertical, four stroke cycle, totally enclosed, direct injection, cold starting, naturally aspirated, gravity feed fuel system with efficient

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paper element filter and force feed lubrication to main and large end bearing and camshaft bush. The specification of the engine has been listed below in Table 2.

Table.2 Specification of Diesel Engine

Make	Kirloskar
Model	DAF 8
Number of cylinder	1
Bore X Stroke (mm)	95 X 110
Rated Output as BS5514/ISO 3046/ ISO 10001	5.9 KW (8.0 HP) at 1500rpm
Compression Ratio	17.5:1
Starting	Hand started with cranking handle
Cubic Capacity	0.78 Lit
Inlet Valve Open (Degree)	4.5 degree BTDC
Inlet Valve Closed (Degree)	35.5 degree ABDC
Exhaust Valve Open (Degree)	35.5 degree BBDC
Exhaust Valve Closed (Degree)	4.5 degree ATDC
Fuel Injection Timing (Degree)	26 degree BTDC

E. Parameters Selection

The parameters required for studying the performance characteristics of the engine were:

- Power produced by the engine
- Engine Speed (rpm)
- Fuel Consumption
- Exhaust Temperature

In order to calculate the performance characteristics the signals recorded from the engine were:

- Voltage generated by the alternator (Digital voltmeter)
- Current generated by the alternator (Digital ammeter)
- RPM of the engine ('MTC' make digital panel tachometer)
- Exhaust gas temperature (Chromel-Alumin K-type thermocouples)
- Fuel consumption rate (Burette)

III. RESULTS AND DISCUSSIONS

This section deals with the results evaluated from the experiment conducted on the test rig and the conclusions derived from the results. The first part deals with calculation of physio-chemical properties and the second part deals with analyses of the performance characteristics

A. Evaluation of Physio – Chemical Properties

The properties that were evaluated in this section were:

- Density
- Kinematic Viscosity
- Calorific value

These properties were calculated for neat diesel, B20, B40, B60, B80 and B100. A comparison table of the properties for diesel, Biodiesel and different blends has been shown in Table 3.

Table.3 Physio-chemical properties of fuels used

Property	Neat Diesel	B20	B40	B60	B80	B100
Density at 15 °C (g/cm3)	0.8317 8	0.8436 74	0.855568	0.867462	0.879356	0.89125
Kinematic Viscosity at 40 °C (CST)	2.8563 81	3.3503 56	3.844331	4.338305	4.832280	5.326255
Calorific Value (MJ/Kg)	45.679 2	44.411	43.143	41.875	40.607	39.339

The results derived after studying the physio-chemical properties were that:

- The density of Biodiesel and its blends was higher than that of diesel
- The kinematic viscosity of Biodiesel and its blends was found to be higher as compared to diesel
- Due to low heating value of Biodiesel the calorific value of biodiesel and its blends was less than that of diesel.

B. Performance Characteristics

The performance characteristics of diesel, biodiesel and its blends were tested on the test engine and the results obtained are described below:

- *Break Thermal Efficiency*

The brake thermal efficiency of various diesels, biodiesel and its blends was calculated and plotted on the graph to analyze the results. The graph has been plotted between break thermal efficiency and break mean effective pressure.

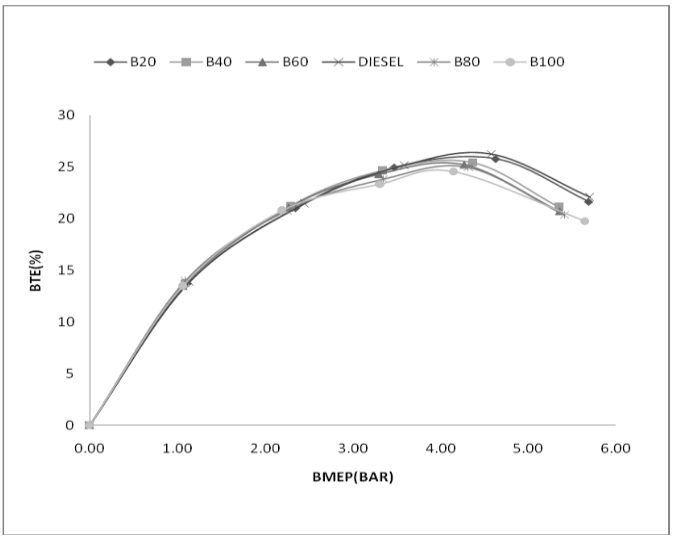

Fig.1 BTE vs BMEP

We can see from Fig.1 that the break thermal efficiency of the fuels firstly increased on increasing the load but after applying about 80 percent load we saw that there was a fall in break thermal efficiency for all test fuels. The break thermal efficiency of diesel was higher than that of biodiesel and its blends. Break thermal efficiency decreased as the percentage of biodiesel in the blend was increased. The peak break thermal efficiency of diesel, B20, B40, B60, B80 and neat biodiesel were 26.25, 25.80, 25.43, 25.24, 24.95 and 24.52.

The reduction in break thermal efficiency with increase in percentage of blend can be because of two causes:

- Biodiesel has high viscosity and low volatility owing to which the ignition delay of biodiesel is large. This causes slow combustion of fuel and consequently the thrust applied on the piston is reduced because of which break thermal efficiency is reduced.
- Another reason is that due to high density of biodiesel the mass flow rate of biodiesel is increased and the product of calorific value and mass flow rate is increased.

- *Break Specific Energy Consumption*

Break specific energy consumption for various test fuels has been calculated and plotted on the graph for comparison and is shown in Fig.2.

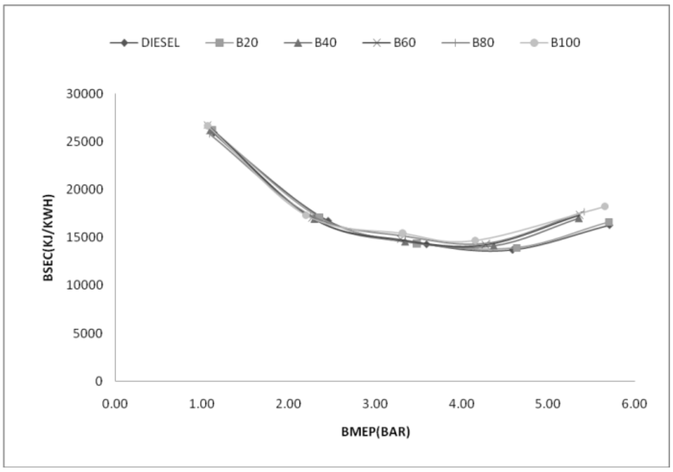

Fig.2 BSEC vs BMEP

It is seen that break specific fuel consumption decreases on increasing the load. The decrease is because, on increasing the load the amount of power produced by the engine is much more as compared to the amount of fuel consumed. The comparison shows that the break specific energy consumption for diesel is least and that for biodiesel is most. It is because the calorific value of biodiesel is less than that of diesel so the amount of fuel consumed at higher load is more.

- *Exhaust Temperature*

The exhaust temperature of all test fuels increased with increase in temperature. The comparison of exhaust temperature produced for all test fuels has been shown in Fig. 3.

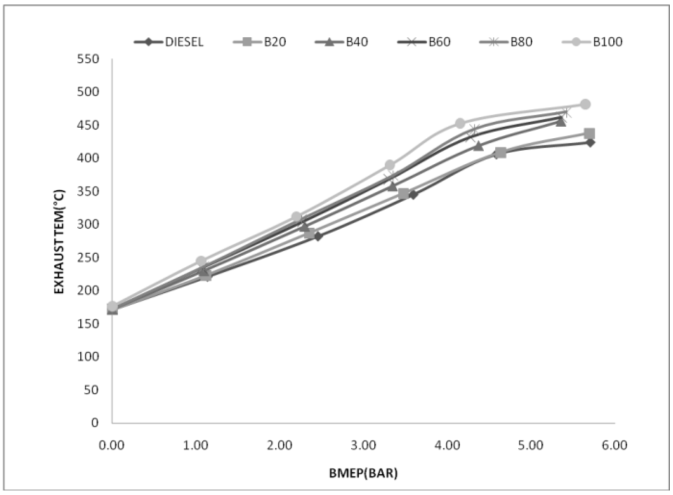

Fig.3 Exhuast Temperature vs BMEP

The increase in exhaust temperature is because on increasing the load the amount of fuel injected in the engine is increased which causes more combustion to take place and consequently more heat is generated in the engine and hence the temperature of the exhaust is increased. It is observed from the graph that the exhaust temperature of biodiesel is more than that of diesel. The reason is that the viscosity of biodiesel is more than that of diesel so the droplets of fuels formed in the engine are of larger size. The process of combustion of the droplets of fuel inside the engine becomes slow and hence the droplets get accumulated in the engine and these droplets when burned together produce high energy and temperature causing exhaust temperature of the engine to increase.

IV. CONCLUSIONS

The performance characteristics of single cylinder compression ignition engine fuelled with yellow grease biodiesel and its blends have been analyzed and compared to neat diesel. Based on the experimental results, the following conclusions were obtained:

- Yellow grease is an attractive option to produce biodiesel because yellow grease is a waste product produced in our kitchens.
- The break thermal efficiency of diesel was higher than that of biodiesel and its blends at all loads because of low calorific value of biodiesel.
- The break specific energy consumption of decreased with increase in load. BSEC increases with increase in biodiesel blends.
- The exhaust temperature of all test fuels increased on increasing load. The exhaust temperature of diesel was found to be less than that of biodiesel blends at all loads.

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