A Comparative Analysis of the Heat Balance Sheet of Blend Methyl Ester of Jatropha Oil with Diesel and Fossil Diesel

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Abstract: ***The aim of this paper is to carry out a comparative analysis of the heat balance sheet of blend methyl ester of Jatropha oil with diesel and fossil diesel. As depletion of non-renewable source of energy (fossil fuel like petroleum fuel, coal, natural gas) many researches are looking forward to find an alternative source of renewable energy, one such alternate diesel fuel is biodiesel. Biodiesel can be defined as fuel comprising of mono alkyl ester of long chain of fatty acid derives from vegetable and non-edible oil. As increase in energy demand stringent emission norms and depletion of oil resources have led the researches to find alternative fuels for internal combustion engine. In the Present Work an experiment work is conducted to obtain the operating and performance characteristics of blend Jatropha biodiesel and compared with diesel fossil on single cylinder diesel engine at constant speed varying load conditions with various blends of Jatropha biodiesel and diesel fuel. It is seen from the present work that the engine performance is improved with significant reduction in unaccountable heat losses for the blend Jatropha oil with diesel as compare to pure Jatropha oil biodiesel without any engine modification***.

Keywords: Jatropha bio-diesel, methyl ester, fuel blends, CI Engine

1. Introduction

In recent past, bio-fuel derived from plant species has been a major renewable source of bio-energy. The utilization of energy crops as a source of renewable fuel is a concept with a great relevance to currant ecological and economic issue at both national and global. This non-conventional source of energy will help in removing in regional imbalance in energy use by making energy available in a decentralized manner. The production of bio fuel will lower national dependence on foreign oil supplier and will reduce emission green house gases scientist have identified some plant that bear seeds rich in non-edible vegetative oil. The natural oils when processed chemically show striking similarities to petroleum derived diesel and are called bio-fuel.

Bio-energy, which is sometime made from energy crops, is mainly a liquid or gas derived from biomass of organic plant material, second generation bio fuel crops. These crops are not typically used for food purpose but can help supply a portion of the current fuel demand sustainably with minimum environment impact (Jespen et al 2006)[a]. The biomass can be converted to fuel and used for various transportation and household purpose. The agro-based fuels are considered an important mean of reducing greenhouse gas emission and energy security by providing an alternative to conventional petroleum based fossil fuel.

Biodiesel production was intended to mainly address the issue of fuel supply security, but recently more attention has been centered on the use of renewable fuels in order to minimize the overall net production of carbon dioxide (co_2) from non-renewable fossil fuel combustion. Furthermore, biodiesel does not increase green house gas levels I the atmosphere because of its closed cycle. In other word it is said to be carbon neutral, as biodiesel yielding plant take away more carbon –dioxide than that contributed to atmosphere, when used as source of energy [1].

2. Biodiesel Production Technology

Today biodiesel is widely produced through transesterification, which is a chemical reaction between triglyceride and alcohol in the presence of a catalyst. As shown in figure.1 it consists of a sequence of three consecutive reversible reactions where triglycerides are converted to diglycerides, and further diglycerides are converted to mono glycerides followed the conversion of mono glycerides to glycerol. In each step an ester is produced and thus three ester molecules are produced from one molecule of triglyceride [2]. Out of these three methods, transesterification is the most viable process adopted known so far for the lowering of viscosity. It also gives glycerol as a by-product which has a commercial value.

Stoichiometrically, three moles of alcohol are required for each mole of triglyceride, but in general, a higher molar ratio is often employed for maximum ester production depending upon the type of feedstock, amount of catalyst, temperature, etc. Commonly used alcohols include methanol, ethanol, propanol and butanol. However, the yield of biodiesel is independent of the type of the alcohol used and the selection of one of these depends on cost and performance. Methanol is preferred over others due to its low cost [3]. The conventional catalysts used are acid and alkali catalysts depending upon the nature of the oil used for biodiesel production.

Another catalyst being studied is lipase. Lipase has advantage over acid and alkali catalysts but its cost is a limiting factor for its use in large scale production of biodiesel. Choice of acid and alkali catalysts depends on the free fatty acids (FFA) content in the raw oil. FFA should not exceed a certain amount for transesterification to occur by an alkali catalyst. Invariably, on all aspects of development of biodiesel, Ma and Hanna [4] have done significant work. Canakci and Van Gerpan [5] reported that transesterification was not feasible if FFA content in the oil was about 3%.

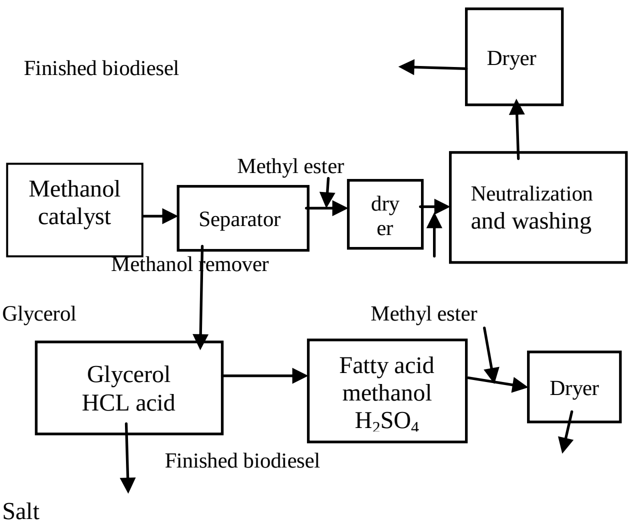

Figure1: Schematic diagram of biodiesel production

3. Biodiesel as Engine Fuel

3.1 Physicochemical Properties of Biodiesel Fuel

The physicochemical properties of biodiesel are similar to those of petro-diesel fuel. Beg et al [7] reported that viscosity is the most valuable property of biodiesel fuel since it has tremendous effect on the operation of fuel injection equipment, particularly at lower temperature where an increase in viscosity leads to poor atomization of the fuel spray and which affects accuracy of the operation of fuel injectors. However the lower the viscosity of the biodiesel, the easier it is to pump, atomizes and achieves finer droplets [7].Sakka and Isayama[8] reveled kinematic viscosity to be an index which measures fuel stickiness , better viscosity values inhibit nebulization of fuel in the ignition chamber, poor values hamper the engine lubrication effects, hence, the viscosity values of the biodiesel must be kept within the stipulation range of international standard specification as shown in table.1.

Table 1: Physiochemical Properties of Jatropha Biodiesel, Blend Jatropha Biodiesel with Diesel and Diesel fossil

Properties	Units	Diesel	B100	B10	B20	B30
Kinematic viscosity at 40ºC	mm^2/s	2.70	4.727	3.713	3.788	3.882
Density at 15ºC	Kg/m^3	833.5	864.8	836.1	839	842.2
Flash point	ºC	65	184.5	80.3	84	86.5
Calorific value	J/kg	44000	39794	43875	43698	43549

*B stands for Jatropha biodiesel blends.

3.2 Stability of Biodiesel

Oxidation stability is an important fuel property which reflects the resistance to oxidation during long-term storage. Usually biodiesels are more sensitive to oxidative degradation than petroleum diesel due to their chemical composition. Fuel quality declines due to gum formation during the oxidation process. This gum does not combust completely resulting in poor combustion, carbon deposits in the combustion chamber and lubrication oil thickening [4]. Monyem *et al.* [10] observed that oxidized biodiesel starts to burn earlier than unoxidised, increasing NO*x* emissions due to the associated increase in viscosity and cetane number. The chemical structure of biodiesel is an important factor in the oxidation reaction. Oxidation is influenced by the presence of double bonds in the chains, that is, feedstock rich in polyunsaturated fatty acids are much more susceptible to oxidation than the feedstock rich in saturated or monounsaturated fatty acids [10]. However, our understanding of oxidation is complicated by the fact that fatty acids usually occur in complex mixtures, with minor components in these mixtures catalyzing or inhibiting oxidation. In addition, the rates of the oxidation of different unsaturated fatty acids or esters can vary considerably. The other factors that affect the oxidation stability of biodiesel include double bond configuration, temperature, air, light and storage tank materials [11].

3.3 Advantages of Biodiesel as Alternative fuel in C.I Engine

The application of biodiesel to our diesel engines for daily activities is advantageous for its environmental friendliness over petro-diesel. The main advantages of using biodiesel is that is biodegradable, can be used without modifying existing engines, and produces less harmful gas emissions such as sulfur oxide . Biodiesel reduce net carbon-dioxide emission by 78% on alife cycle basis when compared to conventional diesel fuel. Other advantages of biodiesel areas follow: portability, ready available, lower sulfur and aromatic content, and high combustion characteristics.

4. Methodology

The methodology used for the present work is purely experimental as we know that the use of biodiesel is an effective way to substituting diesel fuel in the long run. One important conclusion that can be drawn from the work done earlier is that the vegetable oil can`t be use directly in the diesel engine. Several problems crop up if unmodified fuel is used and viscosity is the major factor. It has be found that transesterification is the most effective way to reduce the viscosity of vegetable and non edible oil such as Jatropha seed oil & to make them for their use in the present diesel engine without modification.

In the present work experiment was conducted on single cylinder C.I engine with air cooling system having 5HP of brake power and run of 1500rpm .the pictorial view of setup is shown in figure 2 and engine specification in table.2 given below. Here we using pure Jatropha biodiesel and blend of Jatropha with diesel at concentration B10, B20, and B30 and compared with diesel fossil at six different variables loading conditions and assuming speed of crank shaft remains constant to check the BHP, specific fuel consumption and unaccountable heat was calculated using the collected test data.

Table.2 Engine Specifications

Parameters	Specification
Fuel	Diesel
Type	VRC-1
Number of cylinder	1
Bore	80mm
Stroke	110mm
RPM	1500rpm
BHP	5HP
Power	3.7Kw
Cooling	Air cooled
Lubrication	SAE-30

Figure 2: Experimental setup of single cylinder CI engine

5. Result and Discussion

From figure 3 to 7 shows the curves of engine performance and unaccountable heat for various loading conditions as the function of biodiesel and various blend composition compared with diesel fossil as discussed below.

5.1 Exhaust Gas Temperature

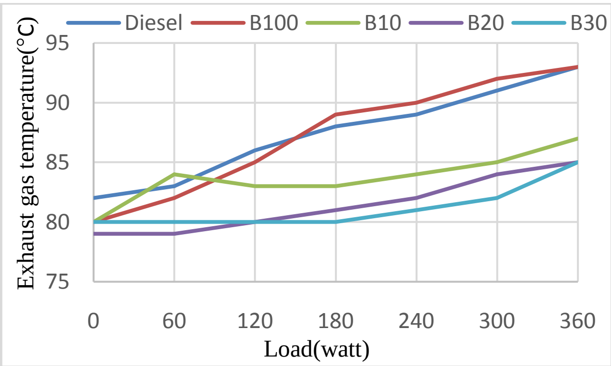

Figure 3: Exhaust gas temperature Vs Load

The variation of exhaust gas temperature with load for the diesel & different blend biodiesel are shown in figure (3).Exhaust gas temperature of fuel increases with the load for all the fuel modes, the exhaust gas temperature of B10, B20 and B30 are lower than that of B100 and conventional diesel fuel. It was found that the lower exhaust gas temperature of B10 and B20 at maximum load condition.

5.2 Brake Specific Fuel Consumption

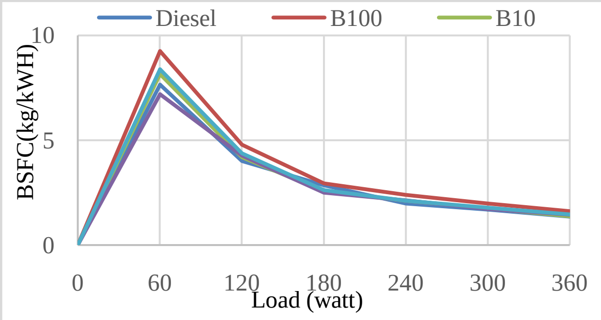

Figure 4: Break Specific fuel consumption Vs Load

The effect of load on fuel consumption capacity of engine at different concentration of biodiesel is shown in figure (4).The BSFC of diesel and biodiesel blends increases with increasing in load and obtain a maximum value up to 60 watt load and then start decreasing. The BSFC of B100 is higher than B10, B20, B30, and Diesel for almost all load condition. This due to lower calorific value of B100 than diesel and blend fuels.

5.3 Brake Horse Power

In the Figure (5) shows the effect of load on the brake power of engine for different concentration values of Jatropha biodiesel and diesel. It is seen from the graph that with increases with load the brake power requirement of engine is monotonically increases. The brake power for B10 is slightly higher than the B20, B30 and Diesel for all loading condition, at load of 180 watt the brake power of B20 is highest and Diesel is in lowest. At maximum loading condition the B10 has higher BHP this due to better combustion of B10.

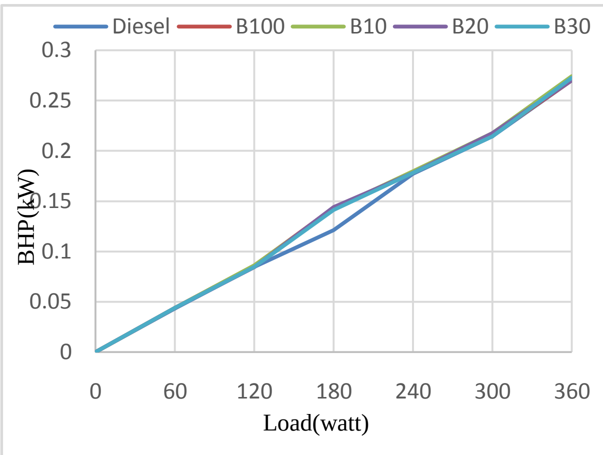

Figure 5: BHP Vs Load

5.4 Air Fuel Ratio

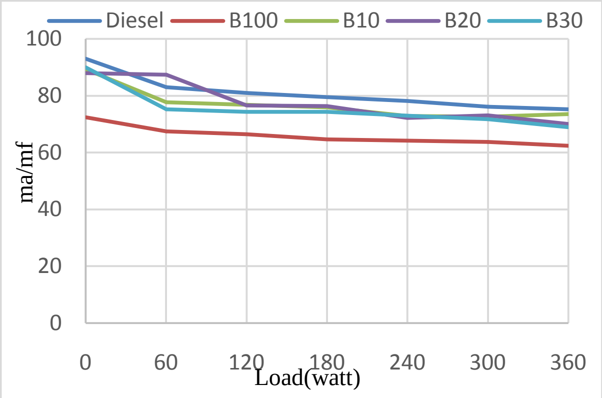

Figure 6: Air fuel ratio Vs Load

The figure (6) shows the variation of air fuel ratio with load for pure Jatropha biodiesel, diesel-biodiesel blends. With increases in load the air fuel ratio is decreases for all tested fuel. The air fuel ratio is estimated on mass basis. It was observed that there was not much variation in air fuel ration in diesel and biodiesel blends, diesel has the maximum air fuel ratio and Jatropha have minimum air fuel ratio this due to more consumption of B100 fuel in diesel engine.

5.5 Unaccountable Losses

A part of heat is loss by convection and radiation. Part of the power developed inside the engine is also used to run the accessories such as lubricating pump, camshaft and water circulating pump. This factor cannot be measured precisely and so these are known as unaccountable losses. The friction power is also not included in heat balance because the friction heat appears partially in the heat to the jacket of cooling water and partially in exhaust. It also rises the temperature of the lubricating oil.

The unaccounted heat energy is calculated by taking the different between the heat supplied and sum of heat carried away by exhaust gas, cooling water and BHP. Heat balance sheet may be prepared in kJ/sec, per minute or on per hour basis. The result of the experiment is presented in a table and this is known as "heat balance sheet". It is general practice to include the heat distribution as percentage of heat supplied in the heat balance sheet.

Equation Used:
Unaccountable heat

$Q = Q_s - (Q_{bp} + Q_w + Q_{eg})$ in kW

Where,
Q_s = Heat supplied in KW
Q_{bp} = Heat carried away by break power in KW
Q_w = Heat carried away by water in KW
Q_{eg} = Heat carried away by exhaust gas in KW

Table 3: Heat Balance Sheets

Performance characteristic	Unit	Diesel	B100	B10	B20	B30
Heat carried away by exhaust gas	KW	.476	.512	.531	.515	.534
Heat carried away by water	KW	.432	.065	.465	.464	.465
Unaccountable heat	KW	2.876	3.662	2.975	2.983	3.299
Q unaccountable heat = $Q_s - (Q_{bp} + Q_w + Q_{eg})$ in kW						
*B stands for Jatropha biodiesel blends.						

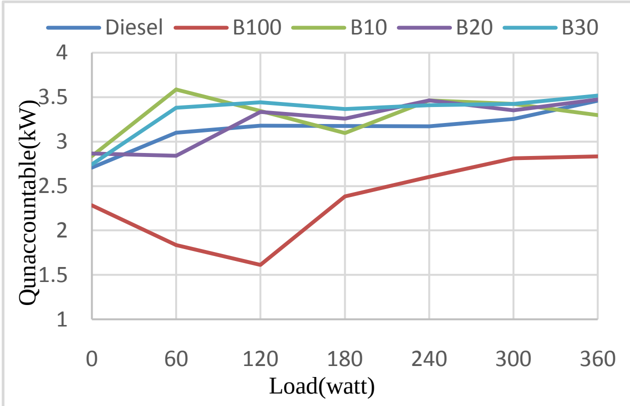

Figure 7: Unaccountable heat (Q) Vs Load

The figure (7) shows there is not much variation on unaccountable heat with increasing in engine load. The minimum value of unaccounted heat is of B100 at 120 watt load, the higher unaccountable heat loss found in B10 at 60 watt load. at maximum loading condition the B30 shows the higher unaccounted heat loss and minimum in case of B100.

6. Conclusion

In this study Jatropha biodiesel has been tested in single cylinder C.I Engine by using Jatropha biodiesel blend the engine operated without any notable problem and heat balance sheet shows that B10 has minimum unaccountable heat compare to B20, B30 and B100. But B10 has value of unaccounted heat near to diesel. From the above calculations it is cleared that B10 represent one of the best alternatives renewable fuel for diesel engine from economics basis without any engine modification. And on the other hand exhaust gas temperature of B10, B20 is lower than that of B100 and fossil diesel at full load condition and hence which reduces the green house gases emission for C.I engine and formation of NO_x.

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Author Profile

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