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Research Article

Performance and Emission Analysis of CI Engine on Mahua Oil Biodiesel

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Abstract

Today the world is facing a problem of the fuel crisis. Everyone is searching new resources of energy generation. The renewable energy source is the best one to overcome the energy crisis. The renewable energy source is readily available in surrounding. As the name renewable, this can be used again and again. The sources of renewable energy are solar, wind, hydro, and bio-fuel. The bio-fuel is the one of such renewable source which trending to minimize the demand of mineral fuel. There is a need to more research in bio-fuel because a number of countries spending their money on purchasing fuel. Biodiesel is one such constituent which replaces the diesel. In India had 23.8 % of forest in India in which edible and nonedible oil trees are abundantly available such as mahua, neem, jatropha, nilgiri, mango and sal etc. out of which edible oil cannot use as a biodiesel due to it had a demand in the food industry. So there is scope to use nonedible oil as biodiesel. The present work is to procure a biodiesel with additive n-butanol from mahua oil as a substitute for diesel. The aim of the paper is to evaluate performance and emission analysis of mahua oil as biodiesel with additive n-butanol. This study is on an odd percentage of blends of mahua biodiesel i.e.B09, B18 and B27. The biodiesel properties satisfy ASTM reference standard 6751.

Keywords: *Transesterification, Butanol Viscosity, Cetane Number, BTE, BSEC, Exhaust Temperature.*

1. Introduction

About a hundred year ago Dr. Rudolf diesel tested an engine with vegetable oil as a fuel. After innovation of low-cost fuel, Diesel is used as a fuel. In World War II vegetable oil is used in vehicles in an emergency situation. The bureau of Indian standards (BIS) evolved a standard (IS-15607) for biodiesel (B100), which is the Indian adaptation American standard ASTM D-6751 and European Standard EN-14214. BIS had published IS:2796:2008 which covers specification for motor Gasoline blended with 5% ethanol and diesel with blended with 10% ethanol.

Biodiesel is nothing but it is a mixture or blend of diesel with bio fuel at fixed which proportion at which their one property (i.e. density, viscosity) getting matches in different biodiesel making process i.e. pyrolysis, micro emulsification, dilution, and transesterification. Biodiesel is the monoalkyl esters of oil. Biodiesel had a reduced level of pollution.

Mahuais non-edible oil due to it contains more fatty acid. Some tribal in Maharashtra, Madhya-Pradesh, Chhattisgarh and Orissa is used as edible oil for cooking purpose. Net energy gain in mahuaoil is 17.7 MJ/Functional units. Global Warming potential (GWP) is 7 times less than diesel. Mahuahas oil percentage varies between 35 % to 45%, Oil has pale yellow in color. This oil solidifies at low temperature in winter. Hence, it is known as "Indian Butter Tree". Madhuca tree height is nearly 20 meter. Almost every part has medicinal uses. Madhuca had two species found in India maduca indica and madhuca longifolia.

Gaurav Dwivedi, *et al*, 2014 is studied the impact of cold flow properties and stability on engine performance. Also, suggested that adding of additives and preheating the biodiesel fuel reduce the effect of cold flow property. This method also helps to reduce viscosity and improve combustion characteristic which results in less carbon deposit and less smoke emission. Puneet Verma, *et al*, 2016 reported that impact of alcohol on properties and performance in engine .cold flow properties using butanol as an additive is improved. As the percentage of butanol is increased its lower viscosities and had a better spray pattern.

2. Methodology

2.1 Preparation of Madhuaca Longifolia biodiesel

Seeds of madhuca tree are collected from a farm located at Hardoli (A) (MH). Crude oil is extracted at oil mill which is located at Tumsar (MH). This oil is transported to Baramati where biodiesel is prepared at Indian Biodiesel Corporation. While preparing

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biodiesel oil is heated at 60^0C to 75^0C for an hour. Oil is mixed with potassium hydroxide (KOH) 0.7% of its volume and methanol 13% to 15% of its volume. After transesterification process biodiesel is yielding around 80% to 84% and the remaining is bi-product is glycerin. While separating biodiesel is washed, soaked, dried and finally distillate. While making an odd number of a blend of 1 liter. B09 with additive butanol, biodiesel is taken as 90 ml biodiesel with 5% butanol (50 ml) and rest of the diesel (860 ml). Biodiesel and butanol are heated together at 40^0C.disel are separately heating at 40^0C. This solution is mixed together and kept settled for 2 hours. After that B09 blend is ready. Similarly, B18 and B27 are procured.

2.2 Cost Analysis

The researcher studied that cost of biodiesel is more than diesel. But some fuel such that Jatropha, Karanja, and Waste fried oil had less cost. But some of them had a higher cost due to they have used food industries and medical industries. The cost of mahua biodiesel is calculated is about 50 Rs. Per liter. There is scope to increase planting of MAHUA trees so their production increases reduce the price of biodiesel.

2.3 Fuel Properties

The researcher reported that biodiesel had two major problems while using in the engine is cold flow property and stability. Biodiesel used in engine affected by high viscosity. These problems can be solved by adding additives or heating a biodiesel. Properties of biodiesel are a very important concern while it used as fuel.

Table 1 Test report of Madhuca oil

Sr no	Test Description	Ref. Std. ASTM 6751	Reference		Madhuca Oil Biodiesel	
			Unit	Limit	Diesel	mahua
1	Density	D1448	gm/cc	0.800-0.900	0.830	0.873
2	Calorific Value	D6751	MJ/Kg	34-45	42.5	37.80
3	Cetane No.	D613	-	41-55	49	51.15
4	Viscosity	D445	mm^2/sec	3-6	2.78	5.30
5	Moisture	D2709	%	0.05 %	NA	NA
6	Flash Point	D93	^{0}C	-	64	143

Properties of mahua according to reference standard ASTM-6751 is shown in table 1. These are in the limit as per suggestion. The viscosity of mahua biodiesel is 5.30 cSt which falls under minimum requirement of biodiesel specification based on ASTM 6751- D445 for viscosity. The colorific value of mahua is 37.80 MJ/kg which is less than 13% of diesel fuel. Blending with butanol additive, calorific is increased. Blend B18 had nearly same CV as that of diesel. The flash point temperature is 143^0C.

2.4 Experimental Setup

Experimentation is carried out in IC engine lab at Vishwakarma Institute of Technology, Pune which is shown in fig.1.

Table 2 Engine Specification

Manufacturer	Kirloskar
No. of cylinder	1
No. of stroke	4
Cylinder diameter	87.5 mm
Stroke length	110 mm
Connecting rod length	234 mm
Fuel	Diesel
Power	3.5 kW at 1500 rpm
Speed	1500 rpm
CR Range	12:1 to 18:1
Injection Point Variation	0 to 25 ^{0} BTDC

The test is carried on a single cylinder, four strokes, water cooled CI engine with compression ratio 12:1 to 18:1 at 1500 rpm. For opacity measurement AVL smoke meter 437 is used .measuring emission of gases such as CO, HC, NO, CO_2 and O_2 five channel gas analyzer is used. The specification is shown in table 2.

Fig.1 Experimental setup at VIT, Pune

3. Result and Discussion

3.1 Brake Specific Energy Consumption

The brake specific energy consumption for different blends of butanol blended mahua biodiesel shown in fig.2. For a full load condition, BSEC observed was at a minimum value. Minimum BSEC noted 0.4, 0.37, 0.37 and 0.38 KJ/KW-Hr for B09, B18, B27 and B100 with respect to the 0.41 KJ/KW-Hr for mineral diesel. At 6 kg load, there is a sharp reduction in a curve for blend B100 because it has low calorific value and there is a chance for random error in measuring instrument.

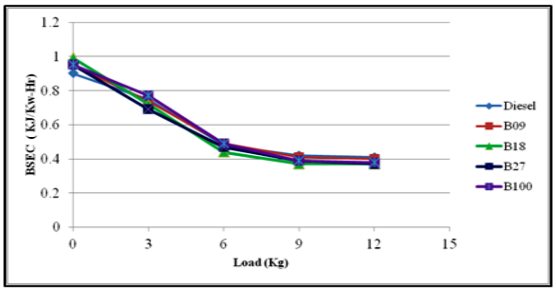

Fig.2 BSEC for diesel and butanol blended biodiesel

3.2 Brake Thermal Efficiency

The brake thermal efficiency for different blends of butanol blended mahua biodiesel shown in fig.3. Decrease the proportion of biodiesel increase in brake thermal efficiency. The maximum BTE noted that 21.45%, 22.91%, 23.01% and 22.31% for B09, B18, B27 and B100 blends with respect to the 20.66% for diesel. The viscosity of mahua biodiesel is higher so there are poor atomization and incomplete combustion, this result to low BTE. But 5% butanol blended biodiesel brake thermal efficiency is slightly higher than diesel. B27 blend had 23.01% BTE which 10% higher than diesel. This is due to butanol blending which characterizes to improve viscosity and atomization.

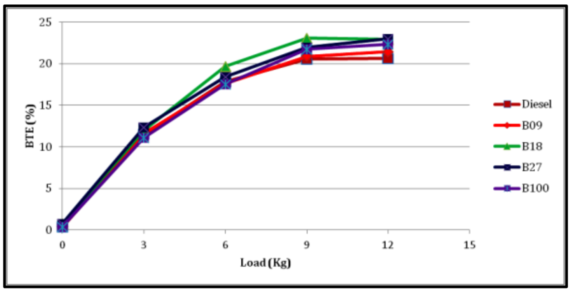

Fig.3 Brake thermal efficiency for diesel and butanol blended biodiesel

3.4 Exhaust Emission

3.4.1. NO emission

Emission point of view nitrogen oxide is a major component.

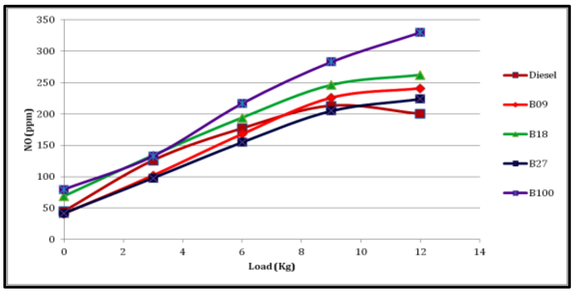

Fig.4 Nitrogen oxide emission for diesel and butanol blended biodiesel

Biodiesel had higher NO emission than diesel. For B100, Nitrogen oxide noted 40 % more than diesel. The B27 blend had 10 % more NO emission than diesel. Biodiesel concentration increase there is an increase in NO emission. NO emission for the different blend is shown in fig.4.

3.4.2. HC emission

Hydro carbon emission for butanol blended mahua biodiesel is slightly higher than diesel. But B100 noted lower than 11% at rated power output. HC emission at full load condition +11%, +10% and -12% for B09, B18, and B27 blend compared to the diesel. HC emission for the different blend is shown in fig.5.

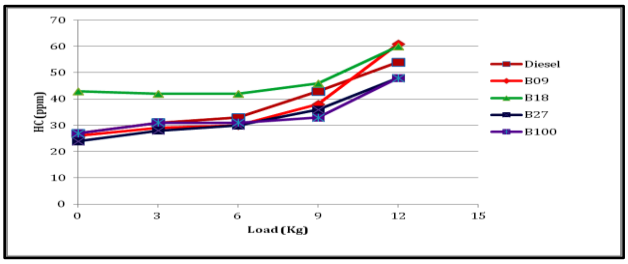

Fig.5 Hydro carbon emission for diesel and butanol blended biodiesel

3.4.3. O_2 emission

O_2 emission for no load is higher than full load condition. Fig.6 shows O_2 emission for different blend at the tail pipe. O_2 emission of biodiesel is slightly higher than diesel.

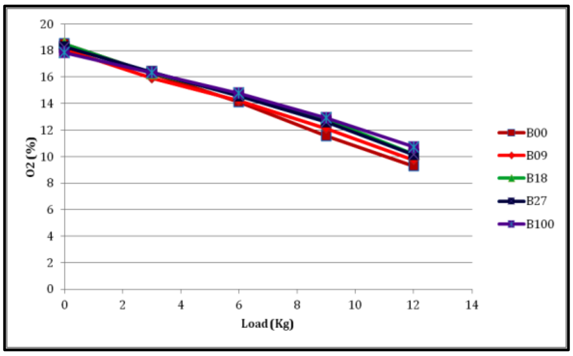

Fig.6 oxygen emission for diesel and butanol blended biodiesel

Conclusions

The increase in biodiesel production decreases the demand for diesel fuel. This is a good strategy for the Indian economy to save capital. Mahua biodiesel cost is approx 50 Rs. Per liter which is less than diesel which is 55.16 Rs. Per liter (Hindustan Petroleum). Mahua Biodiesel fulfills the requirement of properties as per ASTM specification of biodiesel. Following conclusion are drawn on the basis of experimental investigation

1. Reducing the concentration of blend increase in brake thermal efficiency. BTE highest for blend B27 is 28.02% and lowest for B100 is 22.31%.
2. Increasing blend concentration increase in specific energy consumption. B27 yield BSEC 0.37 KJ/KWh.
3. NO is increase as an increase in load and blend concentration. Blend B27 had 10% higher NO emission than diesel.
4. HC emission observed that there is slightly change as the blend concentration changes. But B27 blend had 11% reduction in HC emission than diesel.
5. O_2 emission for no load condition is highest and for full load condition, it is lowest.

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