World Wide Journal of Multidisciplinary Research and Development

WWJMRD 2017; 3(2): 37-41
www.wwjmrd.com
Impact Factor MJIF: 4.25
e-ISSN: 2454-6615

K.C.Keerthivasan
Assistant Professor,
Department of Mechanical engineering, M.Kumarasamy college of engineering, Karur, Tamil Nadu, India

R.Shanmuga Prakash
Assistant Professor,
Department of Mechanical engineering, M.Kumarasamy college of engineering, Karur, Tamil Nadu, India

S.Sakthivelu
Assistant Professor,
Department of Mechanical engineering, M.Kumarasamy college of engineering, Karur, Tamil Nadu, India

S.Sathish Kumar
Assistant Professor,
Department of Mechanical engineering, M.Kumarasamy college of engineering, Karur, Tamil Nadu, India

Correspondence:
R.Shanmuga Prakash
Assistant Professor,
Department of Mechanical engineering, M.Kumarasamy college of engineering, Karur, Tamil Nadu, India

Extraction of bio-diesel from Mahua oil by using trans-esterification process and blended with diesel

K.C.Keerthivasan, R.Shanmuga Prakash, S.Sakthivelu, S.Sathish Kumar

Abstract
This Paper deals with the preparation and blending of Mahua oil using trans-esterification process used as fuel to run an engine from the surveying many literatures as reference we have choose the combination of bio-diesel and diesel. And also we have done performance testing and emission test for this combination. The B20 is a better performed fuel in both the cases also if possible we have replaced the diesel with this vegetable oil as a fuel in our daily practices. We also observe that NO_X gas emission 10% reduced while we compare with regular diesel, the level of O_2 emission will reduced up to 20% similarly smoke opacity got decreased around 8%. Without modifying the engine we got these results if possible we can replace this and it will help to control the air pollution and also avoid the carbon content in the atmosphere.

Keywords: Biodiesel, Mahua oil, Esterification or Trans-esterification, Low emission

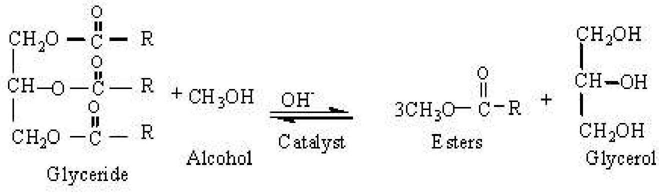
Introduction
The dynamic search for alternate fuels to power the world started with the depletion of the available petroleum reserve under the earth. Transportation segment completely relies on the petroleum oil for power, lubrication etc. as well as other segments too. So the unavailability of the petroleum would be big blow to all. The most favorable alternate fuel biodiesel, is mostly extracted from plants or its extracts or animal fats. Since biodiesel is an oxygenated fuel, it can be utilized without modifications in the prevailing engines. The absence of hydrocarbons, Sulphur, heavy metals or any harmful residues make it environmental friendly. When biodiesel used in engines, CO and soot emission tends to reduce along with the extended engine life. Vegetable oils are used in plain or blended formula as it leads to energy security and independence [1].
Fatty acid methyl esters (FAME) is generally made by esterification reaction by acid catalyst and followed by trans-esterification reaction with pure base catalysts such as KOH or NaOH dissolved in methanol under mild hot conditions. Purification of the fatty acid methyl ester is required. The total cost of this process is not sufficiently higher than the cost of petroleum fuels [2]. Studies are concentrated on several types of fatty acid methyl ester production processes with acid catalysed process, supercritical process [3] and heterogeneous catalyst process [2, 4]. The trans-esterification catalyzed by solid base is one of the promising future technology giving the speedy reaction under normal reaction environments.
In this present experimental investigation, Mahua oil is used to prepare biodiesel using sodium hydroxide as catalyst. The Mahua oil with B20 derived are compared with standards of ASTM. A four stroke single cylinder direct injection diesel engine is used to analyse performance and emission characteristics of experimentation fuel.

Importance of Bio-Diesel
Biodiesel
Bio-diesel is a renewable and natural source of fuel, biodegradable and non-toxic. It is an ester base oxygenated fuel made from any vegetable oil (edible or non-edible) or animal fat. Bio-diesel is produced by a thermo-chemical reaction into vegetable oil and alcohol in the presence of an acid or base as catalyst. It contains of 10% built-in oxygen by weight and has no sulphur and has lubricity properties. Built-in-oxygen makes it more efficient fuel than petroleum fuels hence its cetane number is higher than that of petroleum fuels. It can be

blended with petroleum diesel in any proportion. Bio-diesel is a clean and alternate mode of fuel which may be produced from locally available resources. True biodiesel has no petroleum, but when blended at any level with petroleum then bio-diesel blends are created and can be used in CI engines with minor or no modifications. Biodiesel are synthesised from vegetable oils or fats of animals and are long chain fatty acids of mono-alkyl esters confirming to ASTM D6751 for usagee in diesel engines. Bio-diesel are referred to the pure bio-fuel before blending with diesel. After blended with the same with diesel, biodiesel percentage was represented as B10 and B20. That means biodiesel 10% and 20% and remaining was filled with diesel.

Transesterification process-

Trans-esterification process that has been used in soap and detergent industry consists of natural glycerides with methanol to methyl-esters for their reaction. All bio-diesel fuels are produced in a related chemical praocess using acid catalyzed and base catalyzed transesterification. It is very economical, since it requires lower temperature and pressure with a conversion rate of 98%. The trans-esterification is the reaction of a fatty/oily (triglyceride) with an alcohol to form esters and glycerol. A triglyceride has a 3 long fatty acids of glycerine molecule as its base. The fatty acids attached to the glycerine determines the characteristics of the fat. These fatty acids nature can in turn as affect the biodiesel properties.



Mahua oil and its properties

Madhuca longifolia is found in tropical mixed deciduous forest in many Indian states of like West Bengal, Chhattisgarh, Jharkhand etc. It is also known as Mahua oil. The oil was converted to biodiesel by the following five steps.

- Separation
- Methyl ester wash
- Heating Pre-treatment
- Esterification or Trans-Esterification
- Glycerol

Table 1: Properties of Biodiesel

Properties	*ASTM Standard*	*Biodiesel*	*B10*	*B20*
Kinametic viscosity (mm^2/sec)	2 – 6	38.4	3.6	4.5
Density at 30°C (kg/m^3)	840	912	847	855
Flash point (°C)	>130	186	69	82
Fire point (°C)	-	198	75	88
Calorific value (kJ/kg)	38000-42000	37879.54	42520.22	41871.90

Experimental Setup

Experiment was conducted in four stroke compression ignition diesel engine using diesel, B10 and B20 fuel individually. The diesel engine is single cylinder and water cooled, with maximum power of 3.7 kW at 1500 rpm. Single phase AC alternator was coupled for loading the engine. The rpm/speed of the engine was measured using tachometer and the fuel consumption was measured using a stopwatch and a burette. Using the diesel fuel, experiments was conducted on the diesel engine and appropriate readings are taken. Then B10 and B20 fuel was added to diesel engine and different loads are applied and appropriate readings are taken. The engine was initially operated on diesel and further on blends of Mahua oil as B10, B20. The diverse fuel blends and petro diesel were measured in terms of their performance and emission in the engine. The performance were measured and kept as data for further analysis on brake thermal efficiency, specific fuel consumption and smoke density. Smoke is the major pollutants in the diesel engine exhaust. A special smoke meter was used to quantify the smoke density in the exhaust.

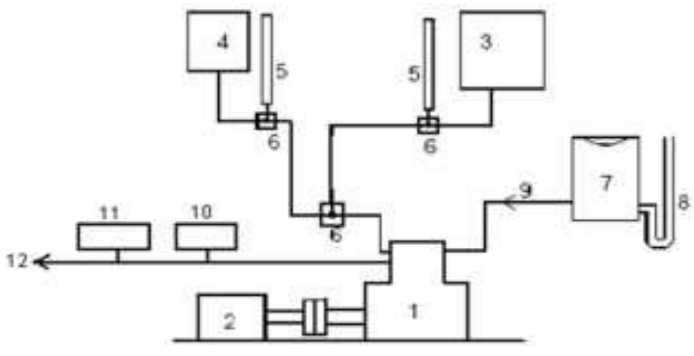


Fig 1: Experimental Setup

1) Test Engine
2) Dynamometer
3) Bio Diesel Tank
4) Diesel Tank
5) Burettes
6) Three way valve
7) Air tank with orifice
8) Manometer
9) Air flow direction
10) Exhaust Analyzer (CO & HC)
11) Smoke meter
12) Exhaust flow

Result and Discussion

The engine performance with diesel, B10 and B20 is evaluated in terms of total fuel consumption, brake thermal efficiency and exhaust gas temperature along with emission characteristics at different loadings.

Brake specific fuel consumption

Blending the biodiesel with diesel was done volumetrically. Engine running on both diesel and biodiesel blends were compared and presented in the Figure 2. It was observed that the diesel BSFC and two blends of biodiesel maintained a correlated trend with reduced BSFC with increased in brake power.

The BSFC of the fuel samples increases with increase in the proportion of biodiesel content in the blend. The higher energy, lower density and lesser viscosity of diesel fuel resulted in generating the lowest average BSFC of 0.445 kg/kWh while running on diesel. The average BSFC of blend B20 was 0.432 kg/kWh, which amounted to 14.3% increase in BSFC compared to diesel.

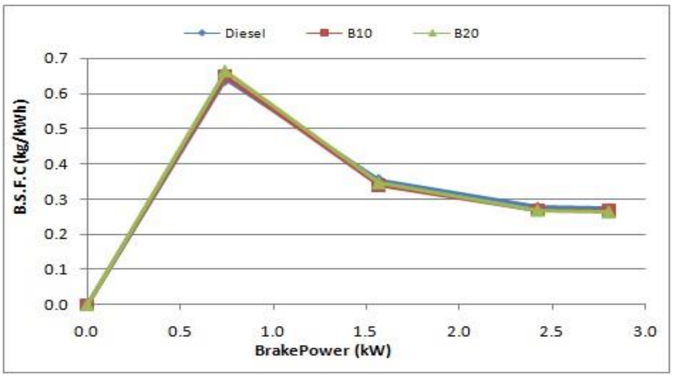


Fig 2: Brake specific fuel consumption vs. Brake power

Brake thermal efficiency

With the increase of brake power, brake thermal efficiency increases for an engine. The brake thermal efficiency for diesel and biodiesel was more or less same as shown in Figure 3. Brake thermal efficiency follows similar trend for all the blends of biodiesel and diesel fuels. Brake power is the ratio of actual brake work per cycle to the amount of fuel chemical energy as specified by the fuel's lesser heating value. This represents the fuel adopted in test engine, altered the fuels chemical energy to mechanical energy with same efficiency.

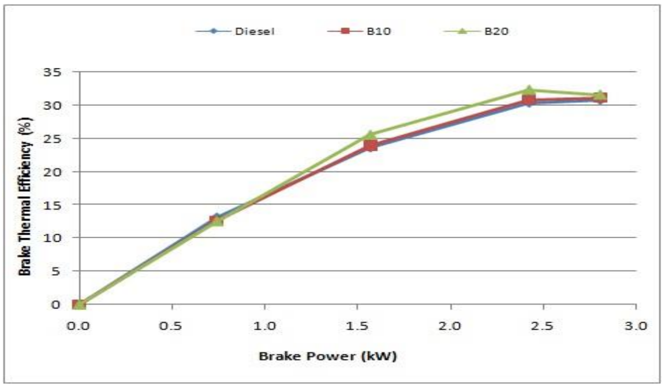


Fig 3: Brake thermal efficiency vs. Brake power

Exhaust gas temperature

We find that the variation of exhaust gas temperature got reduced, when compared to diesel, B10 and B20. Due to the viscosity present in the vegetable oil is shown in Figure 4.

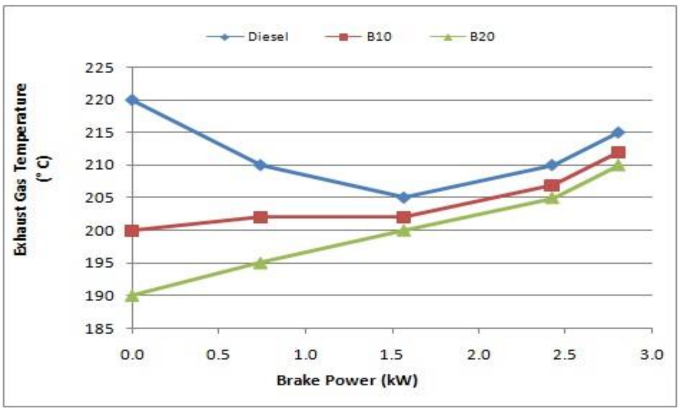


Fig 4: Exhaust gas temperature vs. Brake power

Nitrogen oxide emissions

Increased load increases NO_X emission. Atmospheric nitrogen forms as NO_X at appropriate temperatures by oxidation. Figure 5 shows the emulsified fuels have lesser NO_X emissions than in diesel. Existence of water in emulsified fuels, reduces the formation of NO_X in lesser adiabatic flame temperature.

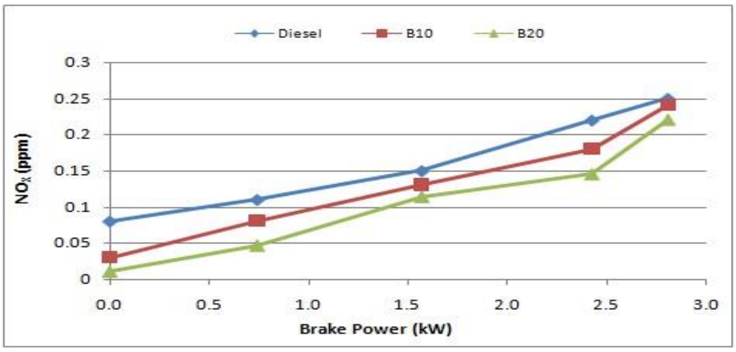


Fig 5: NO_X concentration vs. Brake power

Oxygen emission

Oxygen emission decreases while the load is increased. Due to emission was getting over heated continues running of engine. Compare to diesel and blending of biodiesel, B20 got reduced in the presence of oxygen in the vegetable oil is shown in Figure 6.

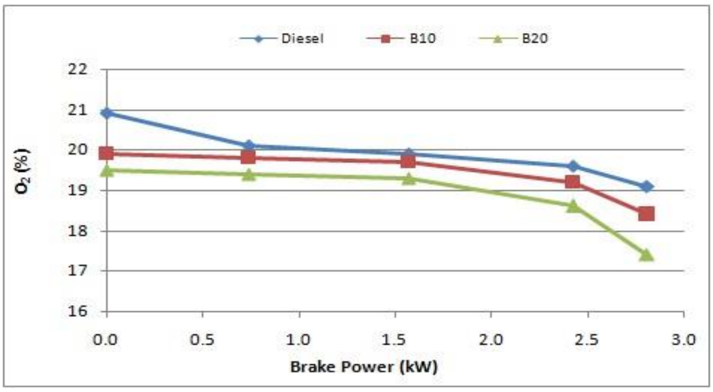


Fig 6: O_2 emission vs. Brake power

Smoke opacity

Figure 7 portrays the graph for different fuels while comparing their loading condition and smoke opacity. The heavier molecules in biodiesel causes higher smoke opacity than diesel. Reduced smoke is found in fuels emulsified with water. This is because water gets evaporated after absorbing the combustion's heat energy.

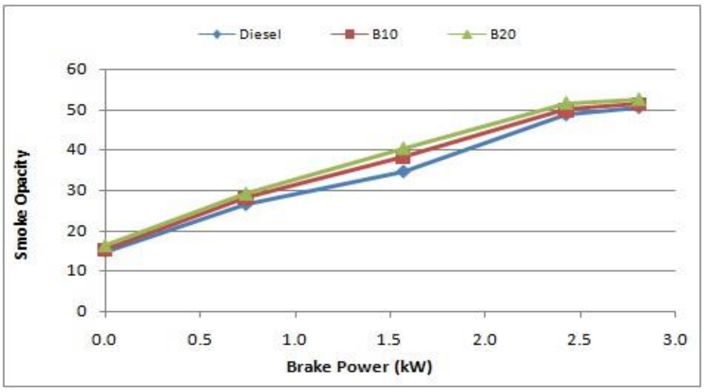


Fig 7: Smoke opacity vs. Brake power

Conclusion

We concluded that the preparation and blending of Mahua oil using trans-esterification process have under gone performance testing and emission test. The B20 is a better performed fuel in both the cases also they have replaced the diesel with vegetable oil as a fuel in our usual practices. We observe that NO_X gas emission 10% reduced while compare with regular diesel, the level of O_2 emission will reduced up to 20% similarly from the result estimate that smoke opacity got decreased around 8%. Without modifying the engine has got better results even if possible of B20 replacement through ordinary diesel which will help to control the air pollution and being as eco-friendly. Finally the evaluation of brake thermal efficiency has been improved 8 -10%.

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