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Performance Evaluation of IC Engine Using Biodiesel from Jatropha as a Raw Material along with Waste Cooking Oil and its Blends

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Abstract: ***In Present work it is proposed to study about the production of biodiesel using Jatropha as a raw material with waste cooking oil and its blends; study of its characteristics and potential as a substitute for Diesel fuel in C I engines. Increase in the consumption and the price hike of petroleum fuel day to day is really problems for developing countries those are dependent on foreign suppliers and pay huge amount of import bill. During the last decade, the use of alternative fuel in diesel engines has received attention. In the last few years interest & activity has grown up around the globe to find a substitute of fossil fuel. According to Indian scenario the demand of petroleum product like diesel is increasing day by day hence there is a need to find a solution. So by using bio fuel as an combustion element this problem can be sorted so we have formulated a process which involves transesterification of Argemone Jatropha plant oil with waste cooking oil & methanol in the presence of a catalyst (NaOH), to yield biodiesel as the main product and glycerin as by-product. Crisis of petroleum fuel and import of fossil fuel is giving a high impact on the economy and development. Besides the economy and development, fossil fuel also leads to a major problem like global warming and change. The emission of harmful gasses like CO, NOx, CO_2, and smoke density causes acid rain, health hazard and also global warming. The high oil price, environmental concern and supply instability. Biodiesel is part of the solution which reduced many of the problems. The objectives of this study are the production process, fuel properties, oil content, engines testing and performance analysis of hybrid biodiesel from Jatropha plant with waste cooking oil. Engine tests will be carried out in a water cooled four stroke diesel engine and experimental investigation have to carried out to examine properties, performance and emission of different blends of hybrid biodiesel .***

Keywords: Biodiesel, Toxicity, Biodegradable, Calorific Value, Brake Specific fuel consumption

1. Introduction

The IC engines are widely used in medium and heavy duty applications as a power source because of their lower fuel consumption and lower emissions of carbon monoxide (CO). In IC engine the thermal energy is released after combustion in the engine cylinder. The combustion depends on the air/fuel mixture and the mixture mainly depends on the quality of fuel and method of its introduction into combustion chamber. The combustion process should be as quick as possible and hence take little time with the release of maximum heat energy. To meet these certain requirements the biodiesel from non edible sources like jatropha, pongamia, neem etc. is used as a alternative to diesel oil in India. The strong advantage of using biodiesel is the independent raw materials are used for their production. The biodiesel improves the emissions of PM and engine performance. Biodiesel can be used as fuel with varying concentrations directly in existing diesel engines. It is produced from raw material by a chemical which removes glycerol from the oil. Jatropha is a very low cost seed with high oil content which grows on good and degradable soils. Jatropha can yield up to 10 times he amount of oil as other sources of biodiesel.

Production of Jatropha seeds and waste cooking oil methyl ester:

Transesterification is the chemical reaction that involves triglycerides and alcohol in the presence of a catalyst to form esters and glycerol. The Flow chart of transesterification process of Jatropha plant is shown in Fig 1. This transesterification involving three consecutive reversible reactions, they are conversion of triglycerides to diglycerides, followed by the conversion of diglycerides to mono glycerides. Glycerides are then converted into glycerol, giving one ester in each step. The overall

Transesterification reaction is given by three consecutive and reversible equations as shown below:

$$\text{Triglyceride (TG)} + \text{ROH} \longleftrightarrow \text{Diglyceride (DG)} + \text{RCOOR1}$$
$$\text{Diglyceride (DG)} + \text{ROH} \longleftrightarrow \text{Mono glyceride (MG)} + \text{RCOOR2}$$
$$\text{Mono glyceride (MG)} + \text{ROH} \longleftrightarrow \text{Glycerol} + \text{RCOOR}$$

The products of the reaction are the biodiesel itself and glycerol.

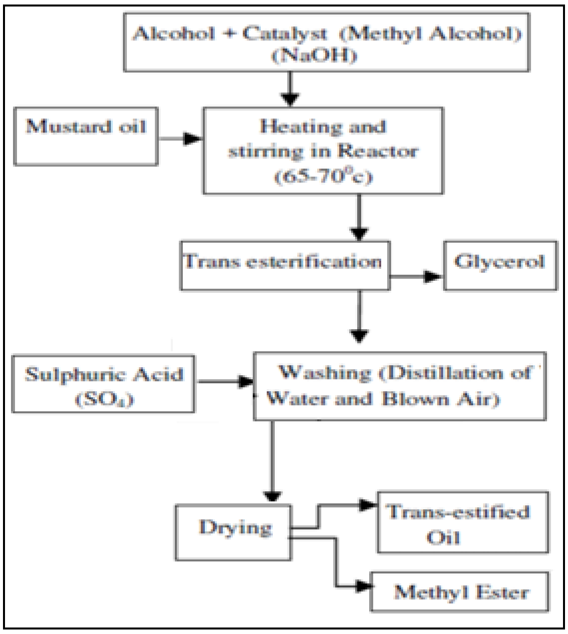

Figure 1: Transesterification Process flow chart

Properties of Jatropha and waste cooking oil compared with diesel

Table 1: Properties of Jatropha and waste cooking oil compared with diesel

Fuel Properties	Diesel	Jatropha plant seeds	Waste cooking oil
Chemical Structure	$C_{10}H_{25}$	$C_{38}H_{44}O_{10}$	C_2H_5-O- C_2H_5
Density(Kg/m^3)	830	884	713
Calorific value(KJ/Kg)	44125	40600	33900
Viscosity(mm^2/sec)	2.7	4.4	0.23
Flash Point (^{0}C)	46	173	40
Fire Point(^{0}C)	52	71	44
Auto ignition temp.(^{0}C)	250	340	160

2. Experimental Setup and Testing

Engine Setup

The experiments were conducted on a four stroke engine. The setup consists of engine connected to hydraulic / eddy current type dynamometer. These signals are interfaced with computer through engine indicator for Pθ, PV plots and engine indicated power, provision is also made for air, fuel cooling water, exhaust temperature, cooling water temperatures and load measurements. Digital indication is provided for temperature measurements. The setup enables study of engine for indicated power, brake power, thermal efficiency, volumetric efficiency, fuel consumption, air fuel ratio, heat balance etc. The software package is fully configurable. The Pθ diagram, PV plot and performance curves are obtained at various operating points.

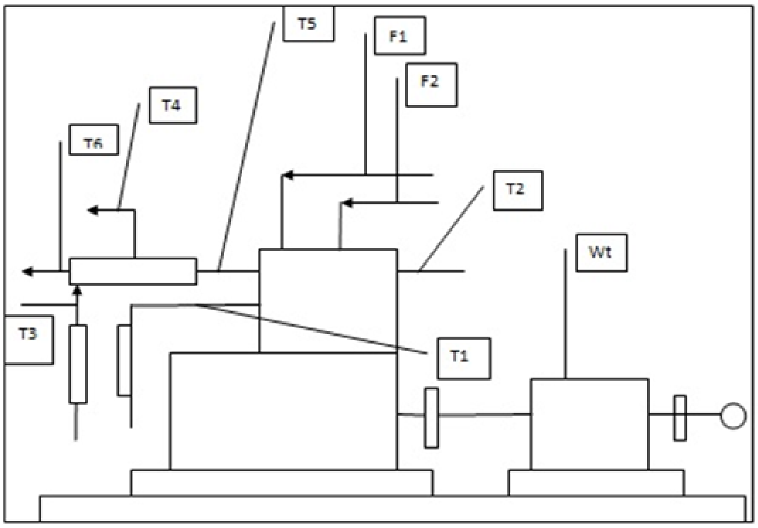

Figure 2: Experimental setup

T1: Jacket water inlet temperature
T2: Jacket water outlet temperature
T3: Calorimeter water inlet temperature
T4: Calorimeter water outlet temperature
T5: Exhaust gas to calorimeter inlet
T6: Exhaust gas from calorimeter outlet Temperature
F1: Fuel flow
F2: Air flow

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Table 2: Engine specification

Engine	Single cylinder, 4 stroke, water cooled, diesel, rated power 5.2 KW, speed 1500rpm, bore 87.5mm, stroke 110mm, compression ratio 17.5, Capacity 661 cc.
Dynamometer	Hydraulic or eddy current type
Carden shaft	for engine and dynamometer
Pezos sensor	Range 1000 PSI, make PCB USA
Crank angle sensor	Resolution 1 deg, speed 5000RPM with TDC marker pulse
Software	For pressure crank angle and PV plots, IP and IMEP calculations, data logging, Printing
Fuel tank	10lit cap with graduated glass fuel metering column
Air box	With orifice meter and manometer
Rota meter	For water flow measurements
Overall size	2.0 m L x 2.5m W x 1.5m H
Temperature indicator	Digital, PT- 100 type temperature sensors (6 points)
Calorimeter	Pipe in pipe type, with rotameter

Experimental testing procedure

The experimental setup consists of single cylinder engine. It is water cooled, direct injection, four stroke diesel engine, eddy current dynamometer will use to give a load on engine ranging from no load, to 100% 0f load .A sensor is connected near flywheel to measure the speed. A thermocouple is used to measure the exhaust gas temperature. The Rota meter is used to measure the flow of incoming water for cooling engine. Emission such as unburnt Hydrocarbon (HC), Carbon monoxide (CO) and Nitro oxide (NOx) were measured by Multi fuel exhaust gas analyzer. Performance parameters such as Mechanical efficiency, Brake thermal efficiency, Brake power, Brake specific fuel consumption, etc. Emission parameters were evaluated by Exhaust gas analyzer. The experiments were carried out by using various blends of Jatropha oil and Waste cooking oil with additives like Methyl ester with additives 10% and 1% Ethanol with Diesel at different load conditions on the engine.

The engine performance test was conducted for all bends separately and performance parameters reading and emission readings were taken.

3. Results

1) At Full load thermal efficiency of blend 4 is high
2) At lower load brake thermal efficiency of Blend 5 is high
3) Brake thermal efficiency of the blend -2 fuel is near about the diesel

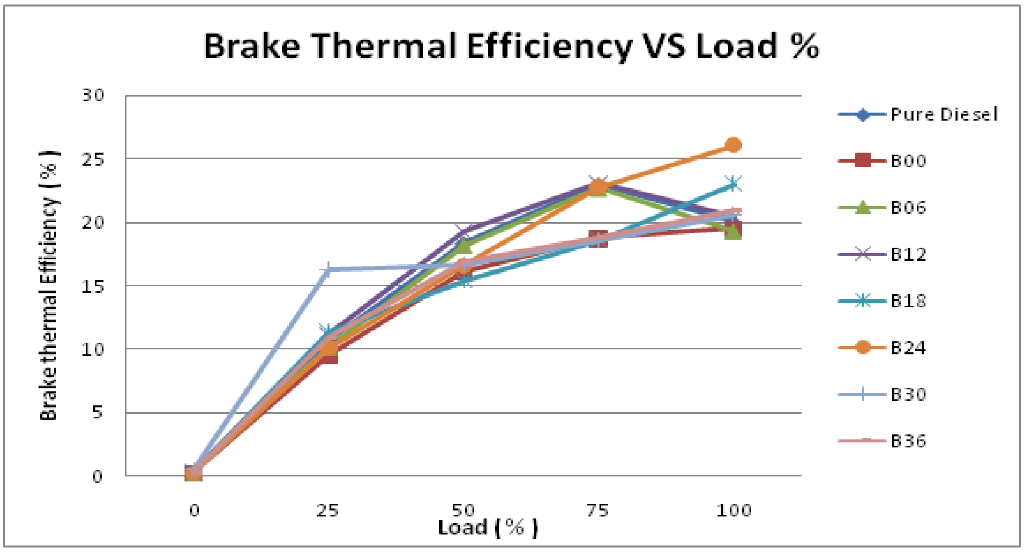

Figure 3: Brake thermal efficiency VS Load %

1) Mechanical efficiency is directly propositional to the load
2) Blend 4 and blend 5 Mechanical efficiency is near about the same.

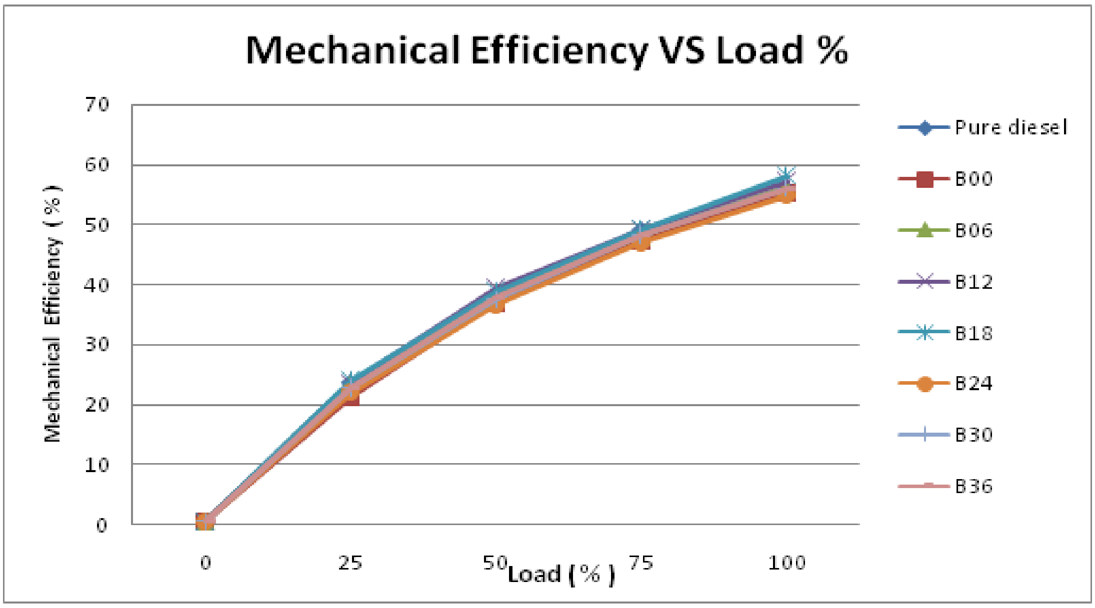

Figure 4: Mechanical Efficiency VS Load %

1) BSFC consumption rate is increased with percentage increased in blending of biodiesel with diesel
2) It is observe that as the load is increasing the fuel consumption is decreasing.
3) At blend 2 it is nearly about diesel BSFC
4) It is observed that B6 is lower than all other blends

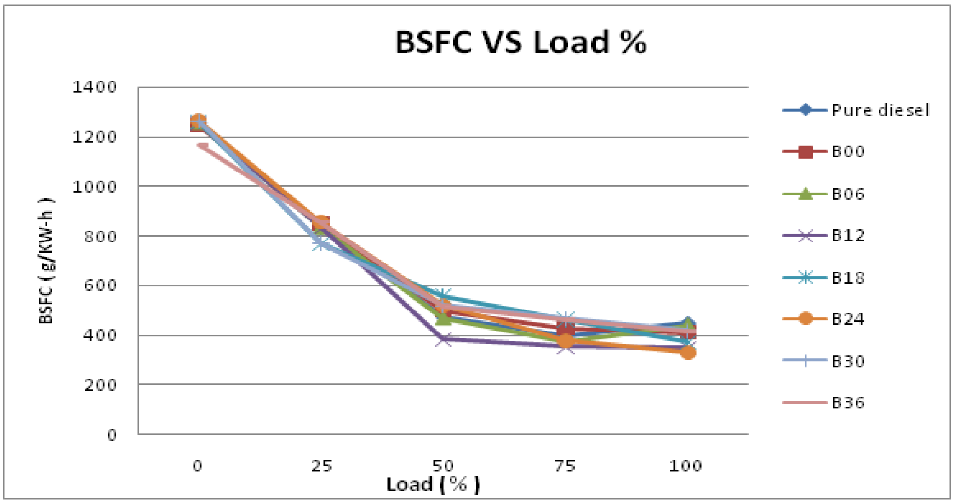

Figure 5: BSFC VS Load %

1) For biodiesel blended fuel, the HC emission is nearly equal to the diesel
2) It is observed that blend 4& blend 5 have nearly equal HC emission as compared to diesel.

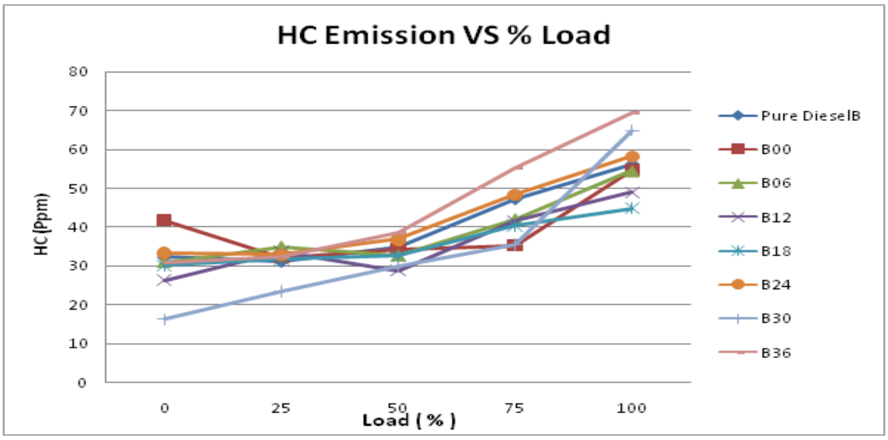

Figure 6: HC Emission VS % Load

1) It increase in percentage of biodiesel oxygen contains increase due to this CO emission is increased.

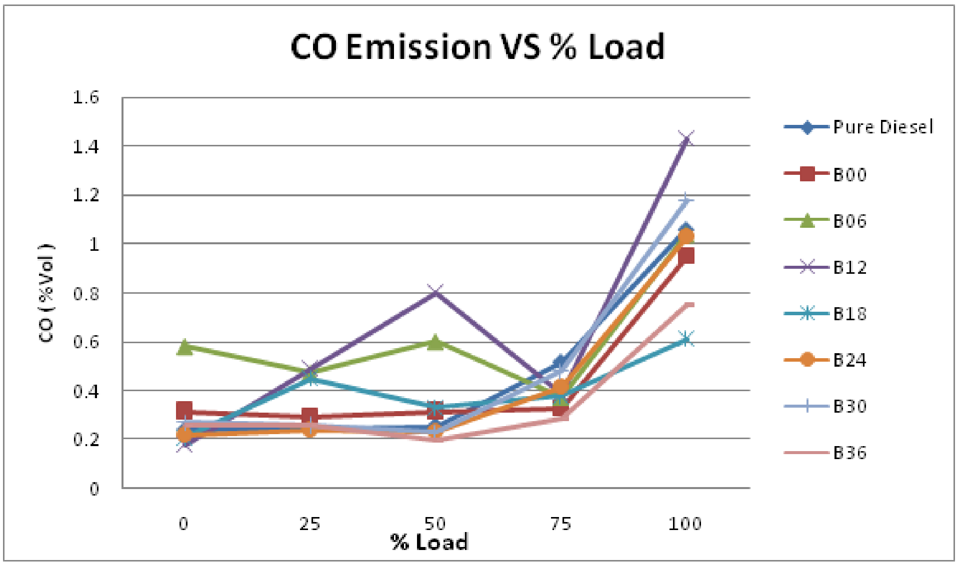

Figure 7: CO Emission vs. % Load

4. Conclusion

Following are the conclusions based on the experimental results obtained

1) The theoretical study of various properties and parameters of blends and also its effects on performance and emission of engine is completed.
2) Then through this study of all the parameters, the modifications of engine parameters are decided and successfully completed the testing on experimental setup.
3) From the results the testing it is concluded that the blend is giving better results for performance of engine as compared to other blends.
4) Blend is giving fruitful results for emission parameter such as CO, HC, CO_2 for both the compression ratios of engine.
5) Lower blends gives lower emission because the biodiesel contain in that blend is very low, which gives results as equal to diesel.
6) Blend Comparatively with all blends performs very well and can be the best alternative fuel.

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