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Experimental Analysis of Engine Performance & Emission Characteristics of Bio-Diesel

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Abstract: **The oil from jatropha is used as a diesel substitute studied from work. The esterification process is used on jatropha oil before mixing with pure diesel in the ratio of 10:90, 20:80 and 30:70 by volume. The properties, like physical and chemical, can be enhanced using plant oil. Compressed ignition engine was run at different Brake power (1, 2, 3,4kw) at a constant speed (1500 rpm) separately on each blend and also on pure diesel with injection pressure (198 bars). From experimental results, it is observed that 20% blend of oil used in engine for combustion shows closer performance to pure diesel. However jatropha oil at 20% blend with diesel gave best performance as compared to 10% blend and 30% blend in terms of emission of HC and CO. All the parameter tested viz., specific fuel consumption, brake thermal efficiency improved. It can be revealed that 20% blend of jatropha oil with diesel can be used as a diesel substitute.**

Keywords: **Bio-diesel, Methyl Esters, Transestrification, engine performance, combustion characteristics.**

1. INTRODUCTION

Fuels derived from renewable biological resources for use in diesel engines are known as biodiesel. Biodiesel is environmentally friendly liquid fuel similar to Petrol-Diesel in combustion properties. Increasing environmental concern, diminishing petroleum reserves and agriculture based economy of our country are the driving forces to promote biodiesel as an alternate fuel. Biodiesel derived from vegetable oil and animal fats is being used in USA and Europe to reduce air pollution, to reduce dependence on fossil fuel. In USA and Europe, their surplus edible oils like soybean oils, sunflower oil and rapeseed oil are being used as feed stock for the production of biodiesel. Since India is net importer of vegetable oils. India has the potential to be a leading world producer of biodiesel, as biodiesel can be harvested and source from non-edible oils like Jatropha curcus, pongamia ,pinnata, Jatropha(Azadirachta Indica), Mahua,Castor, Linseek2d, Kusum, etc. Some of these oils produced even now are not being properly utilized. Out of these plants, India is focusing on jatropha Curcas and Pongamia Pinnata, Jatropha seedoil, which can grow in arid and wastelands. Jatropha oil and its seed contained 30% oil contained. It is untapped source in India [2, 3]. Implementation of biodiesel in India will lead to many advantages like green cover to wasteland, support to agriculture and rural economy and reduction in dependence on imported crude oil and reduction in air pollution [3]. Pryde et al (1982 reviewed the success and short comings for alternative fuel research. However, long term engine test result showed that durability problems were encountered with vegetables oils because of deposit contamination. Thus it was concluded that vegetable oil must either be chemically altered or blended with diesel fuel to prevent premature engine failure.

Blending, cracking, emulsification or transesterification of vegetables oils may overcome these problems. Heating and blending of vegetables oils may reduce the viscosity and improve the volatility of vegetables oils but its molecular structure remains unchanged .Hence, polyunsaturated character remains. On the basis of experimental investigations, it is found that converting vegetable oils into simple esters is an effective way to overcome all the associated with vegetables oils and most of the conventional production methods for biodiesel use basic or acidic catalyst .A reaction time of 45 min to 1 hr and reaction temperature of 55 to 65 degree centigrade are required for completion of reaction and formation of respective esters [5, 6, 7].

Biodiesel consists of alkyl esters of fatty acids produced by the tranesterification of vegetable oils .The use of biodiesel engines required no hardware modification. In addition, biodiesel is a superior fuel than diesel because of sulpher content, higher flash point and lower aromatic content. Biodiesel fuelled engine emits fewer pollutants. Biodiesel can be used in its pure forms or as a blend of diesel. It can also be used as a diesel fuel additive to improve its properties.

Agrawal (3) observed significant improvement in engine performance and emission characteristics for the biodiesel fuelled engine compared to diesel fuelled engine. Thermal efficiency of the engine improved, break specific fuel consumption reduced and considerable reduction in the exhaust smoke opacity was observed.

2. TRANESTERIFICATION

The formation of methyl esters by transesterification of vegetable oil requires oil, 15% of methanol & 5% of sodium hydroxide on mass basic. However, transesterification is an equilibrium reaction in which excess alcohol is required to drive the reaction very close to completion. The vegetable oil was chemically reacted with an alcohol in presence of ak2 catalyst to produce methyl esters. Glycerol was produced as a by-product of transesterification reaction.

CH-COOR1 CH2-OH R1COOR

|

CH-COOR2 + 3ROH Catalyst CH-OH + R2COOR

| | +

CH-COOR3 CH2-OH R3COOR

TRIGLYCERIDE +METHANOL CATALYST GLYCEROL + BIODIESEL

Where, R1, R2 &R3 are long chain hydrocarbons.

The mixture was stirred continuously and then allowed to settle under gravity separating funnel. Two distinct layers form under gravity settling for 24 hr. The upper layer was of ester and lower was of glycerol. The lower was separated out. The separated ester was mixed with some warm water (around 10% volume of ester) remove the catalyst present in ester and allowed to settle under gravity for another 24 hr. The catalyst got dissolved in water, which was separated and removed the moisture. The methyl ester was then blended with mineral diesel in various concentrations for preparing biodiesel blends to be used in CI engine for conducting various engine tests.

3. PROPERTIES OF JATROPHA OIL

Table 1: properties of jatropha and diesel

Properties	Diesel	Jatropha
Specific gravity	0.81	0.87
Viscosity at 20 c (mPa-s)	3.1	3.8
Calorific value (MJ/kg)	42	39
Carbon (%)	86	76
Hydrogen (%)	14	11
Cetane number	45	54

4. EXPERIMENTAL SETUP

The present study was carried out to investigate the performance and emission characteristics of Jatropha methyl ester in a stationary single cylinder diesel engine and to compare it with diesel fuel. Technical specifications of the engines are given below. The engine was coupled to an eddy current dynamometer. HORIBA-MEXA-324 FB was used for the measurement of CO and HC and NOx emissions.

The engine was operated on diesel first and then on methyl esters of Jatropha and their blends. The different fuel blend and mineral diesel were subjected to performance and emission test on the engine. The performance data were then analyzed from the graphs regarding thermal efficiency, break specific fuel consumption and smoke density of all fuels.

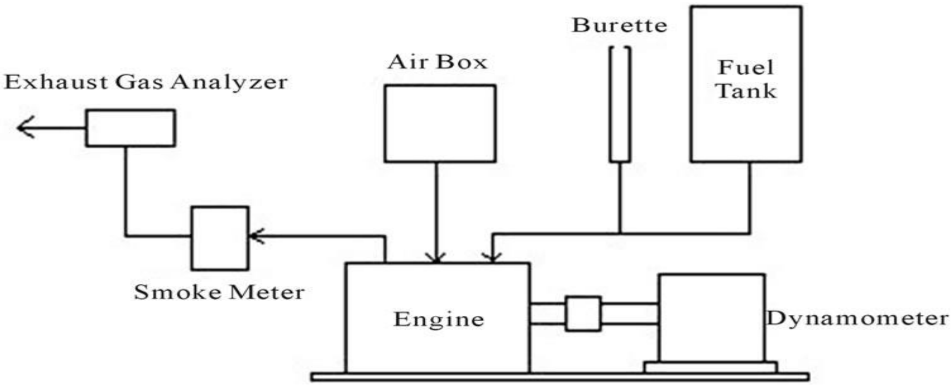


Figure 1. Experimental setup

5. ENGINE SPECIFICATION

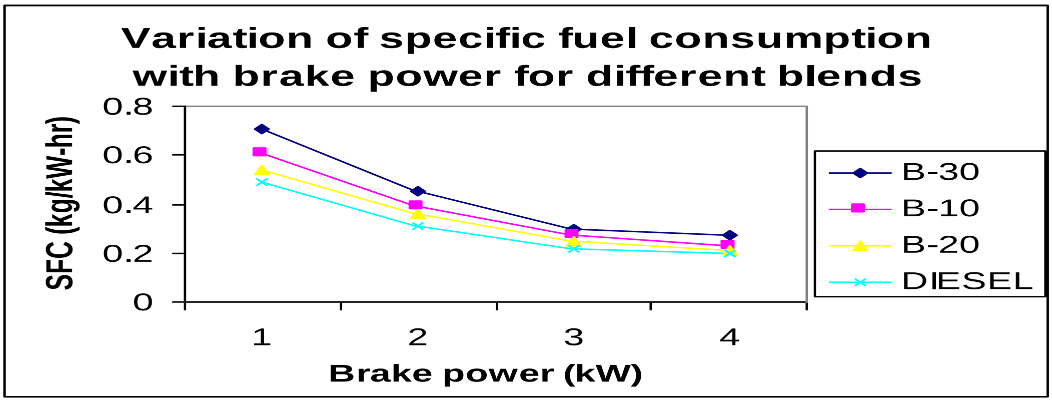
Table 2: engine specification

a)	*Engine parameter*	*b)*	*Specifications*
c)	*Engine type*	*d)*	*Kirloskar, Four stroke, Air cooled*
e)	*No. of cylinder*	*f)*	*Single cylinder*
g)	*Bore*	*h)*	*87.5 mm*
i)	*Stroke*	*j)*	*110 mm*
k)	*Compression ratio*	*l)*	*17.5:1*
m)	*Rated speed*	*n)*	*1500 rpm*
o)	*Rated power*	*p)*	*4.4 kW*
q)	*Dynamomter*	*r)*	*Eddy current*
s)	*Nozzle opening pressure*	*t)*	*195 bar*
u)	*Cubic capacity*	*v)*	*661 cc*

6. RESULT AND DISCUSSIONS

Brake Specific Fuel Consumption:

The variation of the brake specific fuel consumption of diesel and various blends of Jatropha and diesel oil at different loads is shown on Figure. It is found that the specific fuel consumption for the blend B20 is close to diesel at full load. However at part load conditions the variations are appreciable for all the blends. Also if the concentration of Jatropha oil in the blend is more than 20 % the variations in the specific fuel consumption are significant. This is because of the combined effects of lower heating value and the higher fuel flow rate due to high density of the blends. Higher proportions of Jatropha oil in the blends increases the viscosity which in turn increased the specific fuel consumption due to poor atomization of the fuel.



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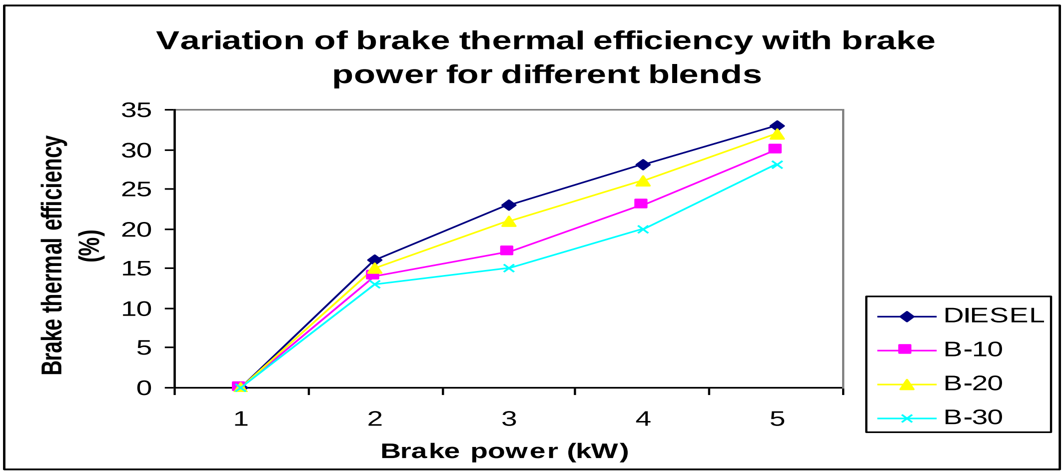
Graph 1: Variation of specific fuel consumption witrh brake power for different blends

Brake Thermal Efficiency:

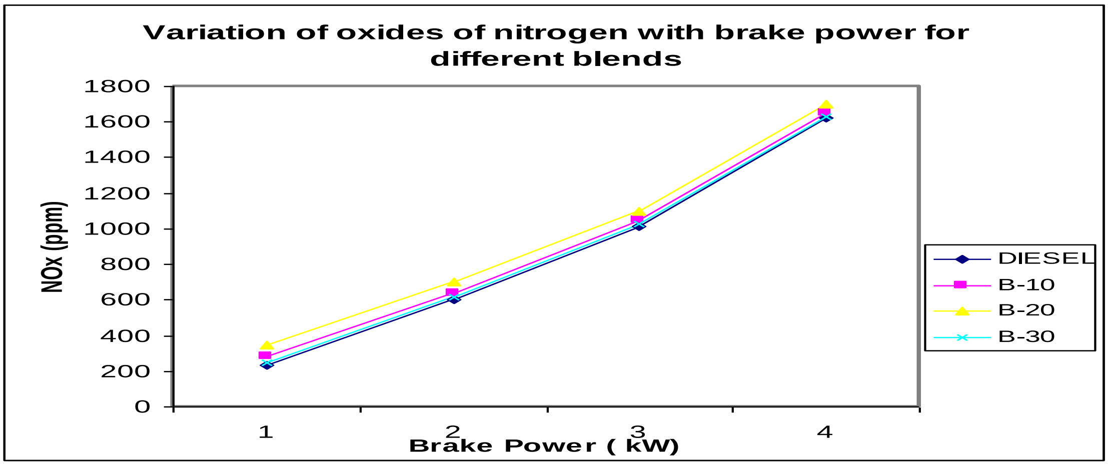
The variation of brake thermal efficiency of the engine with various blends is shown in Figure and compared with the brake thermal efficiency obtained with diesel. It shows that brake thermal efficiencies of all the blends are lower at all load levels. The decrease in brake thermal efficiency with increase in Jatropha oil concentration is due to the poor atomization of the blends due to their high viscosity. However it is found that Brake thermal efficiency for the blend B-20 is close to diesel due to high presence of oxygen and better combustion.



Graph 2: Variation of brake thermal efficiency with brake power for different blends

Oxides of Nitrogen:

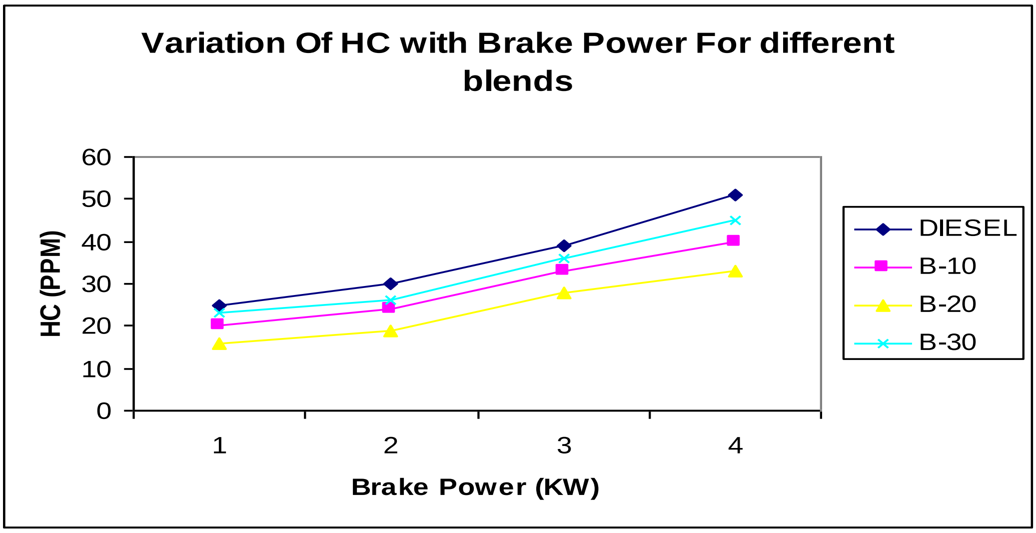
The variation of NO_x emission for different blends is indicated in Figure. The NO_x emission for diesel and all the blends followed an increasing trend with respect to load. For the blends an increase in the emission is found at all loads when compared to diesel. The main reason for NO_x formation is high presence of oxygen and high temperature. Since the exhaust gas temperature is higher for B20 and presence of oxygen is higher that's way the NO_X emission is also higher. This resulted in higher NO_x formation.



Graph 3: variation of oxides of nitrogen with brake power for different blends

Hydrocarbons:

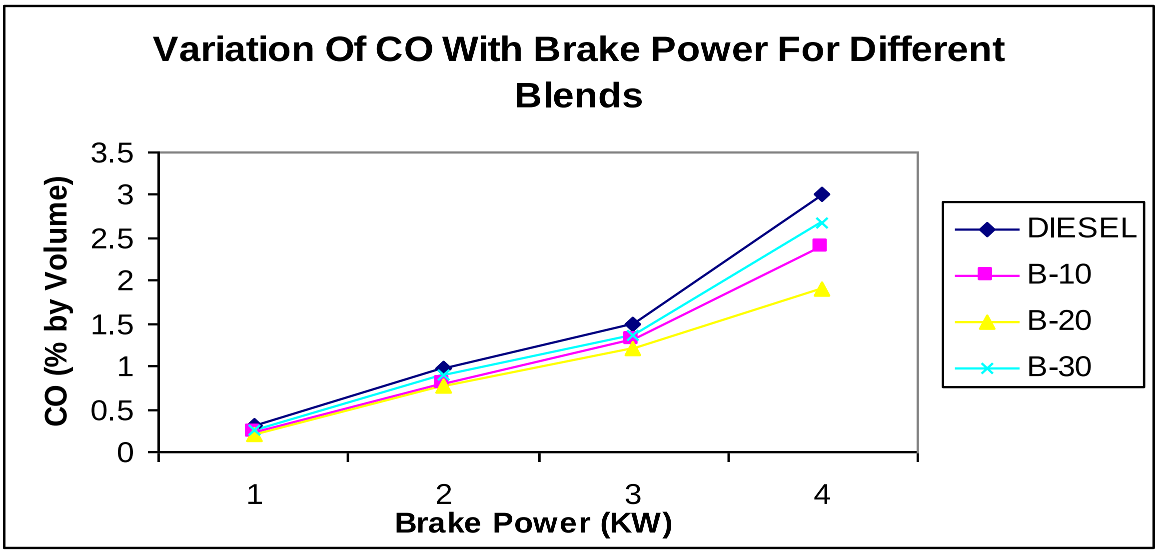
The variation of hydrocarbon emission with brake power for different blends is shown in Figure. The graph shows that the hydrocarbon emissions of the various blends are lower than the diesel fuel. Hydrocarbon emission variations are due to the carbon and hydrogen content of the fuel. The fuel blends (B30, B20 and B10) have the lower carbon residue and hydrogen than the diesel fuel and higher oxygen contents. So the hydrocarbon emissions of the blends are lower than the diesel fuel at all load conditions. The B20 has the lowest hydrocarbon emission than the other fuels because of better combustion and B30 has high due to improper combustion.



Graph 4: variation of HC with brake power for different blends

Carbon monoxide:

The variation of carbon monoxide emission with brake power for different blends is shown in Figure. The graph shows that the carbon monoxide emissions of the various blends are lower than the diesel fuel. Carbon monoxide emission variations are due to the carbon content of the fuel and presence of oxygen. The fuel blends (B30, B20 and B10) have the lower carbon residue and hydrogen than the diesel fuel. So the carbon monoxide emissions of the blends are lower than the diesel fuel at all load conditions. The B20 has the lowest hydrocarbon emission than the other fuels because of better combustion and B30 has high due to improper combustion.



Graph 5: variation of CO with brake power for different blends

7. CONCLUSION

METHYL ESTERS OF Jatropha oil at 20% blend with diesel gives best performance in terms of high thermal efficiency; low fuel consumption, emission of HC and CO., specific fuel consumption, and brake thermal efficiency were almost equal when engine was run on pure diesel.

The transesterification process, used for making bio-diesel, is simple and cost effective to solve viscosity problems encountered with vegetable oils.

The cost of dual fuel can be considerably reduced than when pure diesel is used.

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