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Effect on Performance and Emission Characteristics of Direct Injection using Biodiesel Produced from Kranja oil

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ABSTRACT: IC engine became an integral part of our daily life in industrial, agriculture and transportation. To run this engine we required energy which is available in the form of chemical energy as fossil fuels. Presently the consumption of fossil fuels are increasing drastically, their prices are hiking day to day and exhaust emission emitted by IC engine effected so badly our greenhouse gases and cause global warming. Biodiesel is found to be best alternative fuel for petro-diesel which can be used to run CI engine either directly or blended.The main objectives of the present work are to produce biodiesel from *Pongamia pinnata* (Karanja) oil using esterification followed by transesterification. Various proportions of Karanja oil methyl ester blends (10%, 20%, and 30%) were used for conducting the performance test at varying load conditions. The experimental result shows that B20 blend was found to be the best and effective blend which improves the brake thermal efficiency and reduced brake specific fuel consumption and also reduced all exhaust emissions like CO, CO_2, HC and smoke, but there was increase in smoke density and NO_x as compared to neat petro-diesel.

Keyword: Biodiesel, karanja oil, performance, emissions.

I. INTRODUCTION

The rising cost as a result of depleting fossil reserves as well as problems relating to greenhouse gas emissions have been the most important drivers for seeking out new sources of energy [1].

Stringent emissions standards such as the newly proposed tier 3 standards by the Environmental Protection Agency (EPA) indicate that fuels that burn cleaner and have lower sulfur content will be favored [2-3]. A variety of alternative sources of energy, ranging from wind, solar, nuclear, etc., already exist but several challenges such as capital, portability, inefficiency, storage, and further environmental degradation make these sources of energy inadequate and in some cases non-viable [4-6]. Further, IC engine play a very important role in our life. All sector like industrial, agriculture, transportation and all other sector dependent upon IC engines. Fossil fuels are the major resources to run the IC engine but their consumption increases rapidly and their producing reservoirs are vanishing day to day [6-7]. For internal combustion (IC) engines, liquid biofuels have emerged as viable alternatives to fossil fuels. Biofuels are fuels typically made from renewable sources such as animal feedstock, plants, and biomass. Biofuel production and consumption has increased in recent years partly as a result of government support in the form of tax credits, mostly because they have been found to effectively supplement current fossil fuels [8-10]. Biodiesel is a type of biofuel made from the trans-esterification process and involves reaction of a feed stock, usually oil or fatty acids from oil, with an alcohol in the presence of a catalyst [11-13]. The end product of the trans-esterification process is a fatty acid methyl ester (FAME), also called biodiesel. Biodiesel has several benefits over conventional fossil diesel; it is renewable, non-toxic, has greater lubricity, generally lower emissions and most of all has similar properties to convention fossil diesel [14-16].

Many researchers have used different vegetable oil like sunflower, castor, soybean, jatropha, mahua etc. for the production of biodiesel [17-20]. In country like India where food consumption has deficiency we can’t produce biodiesel from edible oil. So it is compulsory to produce biodiesel from non-edible oil. *Pongamia pinnata* (Kranja) is the non-edible oil which was grown in Rajasthan.

It was found that very less number of literatures was found for the production of biodiesel and engine performance and emission characteristics from karanja oil [21-24]. In this study, firstly two-step transesterification method was used to produce biodiesel from karanja oil because FFA content of karanja oil is greater than 5%. Engine performance and emission characteristics were analyzed by CI engine using biodiesel produced from karanja oil.

II. EXPERIMENTAL

(i) Production of biodiesel

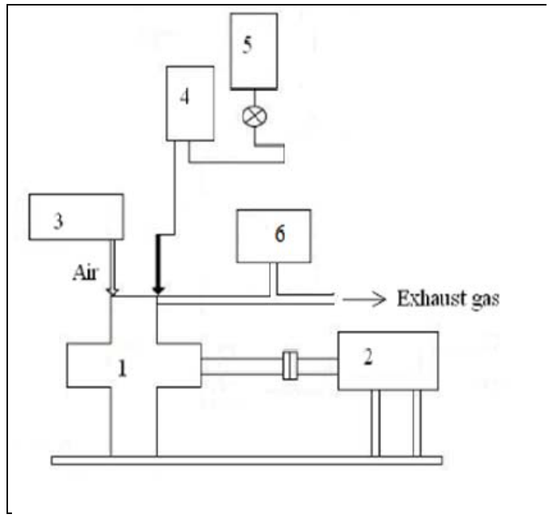
The production of biodiesel was done by two-step transesterification process. Basically the Oleic acid and Linoleic acid are 53% and 18% are the major composition of mono unsaturated acids while minor composition like Palmitic acid and Stearic acid are 13% and 7% respectively represents the saturated acids [22-23]. Two-step transesterification process was used for the production of biodiesel. Production of biodiesel was done at reaction time of 2 hr, catalyst-NaOH (1% wt.) and reaction temperature 68^0C and molar ratio 1:8. The physical properties of biodiesel was compared with ASTM standards as shown in the Table 1.

Table 1: Properties of biodiesel.

S.no	Properties	Units	Karanja oil	Karanja biodiesel	ASTM standards D 6751
1	Acid value	mg of KOH/ gm of oil	16.66	0.5	0-.5
2	FFA	%age	8.33	0.25	<0.5
3	Iodine value	gm of Iodine /100gm of oil	206	185	120
4	Density (40^0 C)	kg/ m^3	935	897	880
5	Kinematic viscosity (40^0C)	cSt	41	5.4	1.9-6

(ii) Engine set up

Fig. 1 shows schematic diagram of the experimental setup.The engine set up shown is single cylinder water cooled diesel engine. The engine has rated output 5.2kw at speed 1500rpm with compression ratio 17.5, injection pressure 180kg/cm^3 and coupled with rope break dynamometer. The detailed specification of engine is given in Table 2. Performance test are carried out on compression ignition engine using various blends of biodiesel and diesel as fuel.



1. Engine 2. Dynamometer 3.Air plenum 4.U-tube manometer 5. Dual biodiesel tank 6.Exhaust gas analyzer

Fig. 1. Experimental setup.

Table 2: Engine specifications.

Engine speed	1500 rpm
BHP	5
Bore	80mm
Stroke	95mm
No. of cylinder	1
Dynamometer	Mechanical loading
Drum dynamometer	28 cm
D_o	24mm
C_d (Coefficient ofdischarge)	0.6

Emission such as carbon dioxide, carbon monoxide (CO) nitrous oxide (NO_x) and unburned hydrocarbon (HC) were measured by an exhaust gas analyzer and smoke density was measured by smoke meter. Initially, the engine was started on neat diesel fuel and warmed up, once the engine was reached the stabilized working condition. Then parameters like the speed of operation, fuel consumption, engine load and exhaust emission were measured. Further the experiment was repeated for B10, B20 and B30 blends.

III. RESULTS AND DISCUSSIONS

(i) Engine Performance.

The biodiesel obtained from karanja oil by two step transesterification was blended with petro-diesel in three different portions, i.e., 10%, 20%, 30% by volume. For obtaining karanja biodiesel blend B-10, 90% of diesel is mixed with 10% of karanja biodiesel by volume. Similarly for B20 and B30 blend were obtained. The properties of the different blends (B10, B20 and B30) and petro-diesel are measured as per ASTM standards for experimentation as shown in Table 3.

Table 3: Fuel properties of the petro-diesel, karanja biodiesel, B10, B20 and B30.

S. no	Properties	Units	Petro-Diesel	Karanja biodiesel	B10	B20	B30
1	Density $(15^0 C)$	kg/m^3	850	897	854	860	864
2	Kinematic Viscosity (40^0C)	cSt	2.6	5.4	2.88	3.16	3.44
3	Flash Point	degree centi	65	115	71	79	86
4	Calorific value	MJ/kg	42	37.5	41.55	41.1	40.65

(ii) Brake thermal efficiency

Figure 2 represents the brake thermal efficiency vs. load. It was found that as the load on the engine was increases the BTH is increasing. It is found that karanja B20 blend shows the maximum BTH at higher load as compared to all other fuels (B10, B30 and petro-diesel). it was concluded that the oxygen present in the biodiesel improved combustion which results higher pressure rise and heat releases rate as compared to neat diesel which results more BTH in karanja B20 as compared to diesel at full load. It was found that at higher load in case of B20 the BTH was 28% as compared to neat diesel was 27.2%.

(iii) Brake specific fuel consumption

Figure 3 shows the BSFC vs. load. It is clear from figure that at low load in case of biodiesel due to poor atomization, the more BSFC is required as compared to neat diesel. On the other side as the load on the engine is increase the BSFC start decreasing. It is found that at full load the BSFC is almost same in all fuels.

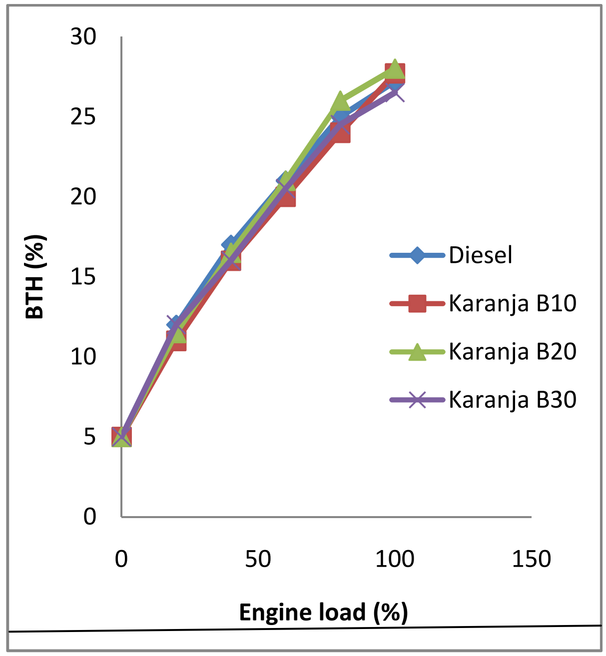


Fig. 2. Brake thermal efficiency vs. load.

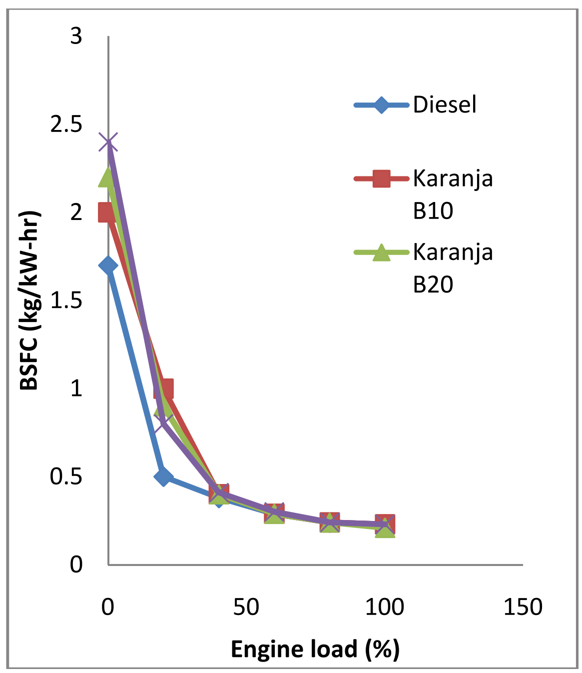


Fig. 3. Brake specific fuel consumption vs. load.

(iv) Exhaust gas temperature

Figure 4 represents the exhaust gas temperature vs. engine load. It is clear from figure that as the load on the engine increases the EGT is also increases. It is found that at higher load karanja B30 blend has higher EGT than all fuels.

It was concluded that oxygen present in the cylinder improves the combustion quality which result in higher peak pressure and heat release rate. Thus higher EGT was found in karanja biodiesel as compared to neat diesel. It is found that at higher load in case of B30 the EGT was 370 °C as compared to neat diesel 330 °C.

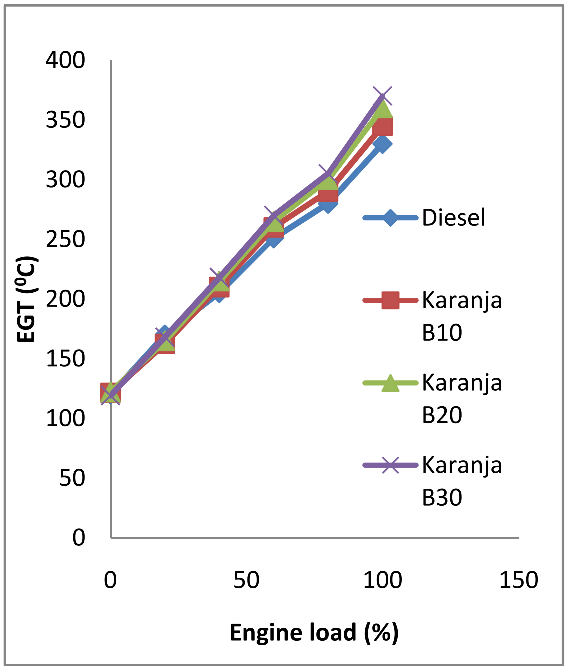


Fig. 4. Exhaust gas temperatures vs. load.

IV. ENGINE EMISSIONS

(i) Carbon dioxide

Figure 5 shows the carbon dioxide vs. load. It is clear from figure that as the load on the engine increases the carbon dioxide increases. It was found that at higher load in case of biodiesel blends the carbon dioxide concentration is decreases n as compared to neat diesel. It was found that at higher load in case of karanja B30 the carbon dioxide was 3.05% as compared neat diesel was 3.5%.

(ii) Carbon monoxide

Figure 6 represents the carbon monoxide vs. load. It is clear from figure that as the load on the engine increases the carbon monoxide concentration decreases. Higher viscosity, density and evaporation energy of biodiesel results in inadequate fuel–air mixing, especially at lower engine speeds and loads which results higher concentration of CO at lower load. On the other side, at higher load oxygen present in the biodiesel enhance the combustion quality which results complete combustion take place inside the cylinder in case of biodiesel as compared to neat diesel.

It was found that at higher load in case of B30 the less concentration was observed as compared to all fuels.

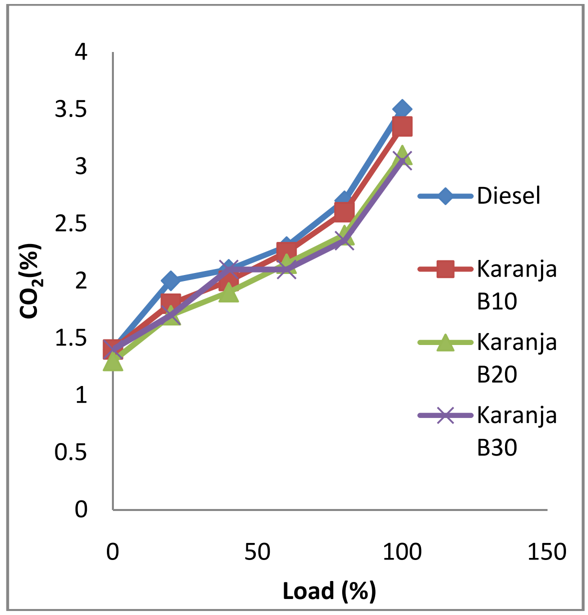


Fig. 5. Carbon dioxide vs. load.

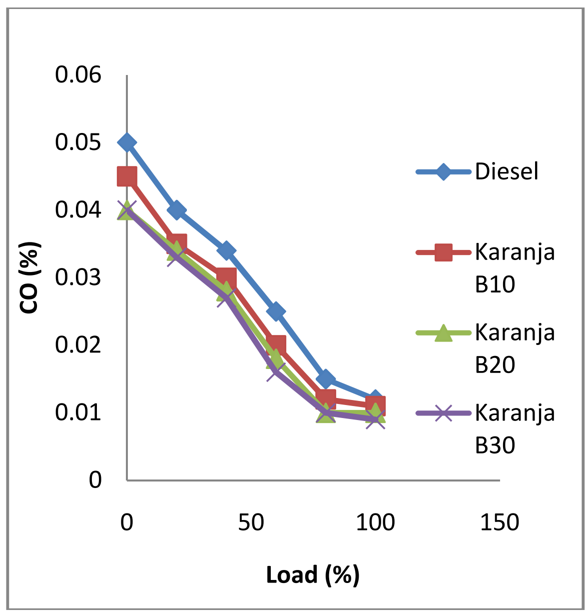


Fig. 6 Carbon monoxide vs. load.

(iii) Unburned hydrocarbon

Figure 7 represents the unburned hydrocarbon vs. load. It is clear from figure as the load in the engine is increases the unburned hydrocarbon decreases. Reduction in over-mixing at lower engine loads due to poor biodiesel volatility.

(b) Reduction in stoichiometric air requirement owing to fuel-bound oxygen in biodiesel, which enhances diffusion combustion and also increases heat release/gas temperature as compared to mineral diesel. At higher engine loads, oxygen present in biodiesel molecules helps in reduction of HC emissions, when the HC emissions are mainly caused by deficiency of oxygen in the fuel-rich zones. It was found that hydrocarbon is almost similar in case of B20 and neat diesel as compared to all fuels. It was found that in case of B20 blend the oxygen present in the biodiesel improves the combustion which results less hydrocarbon as compared to all fuels.

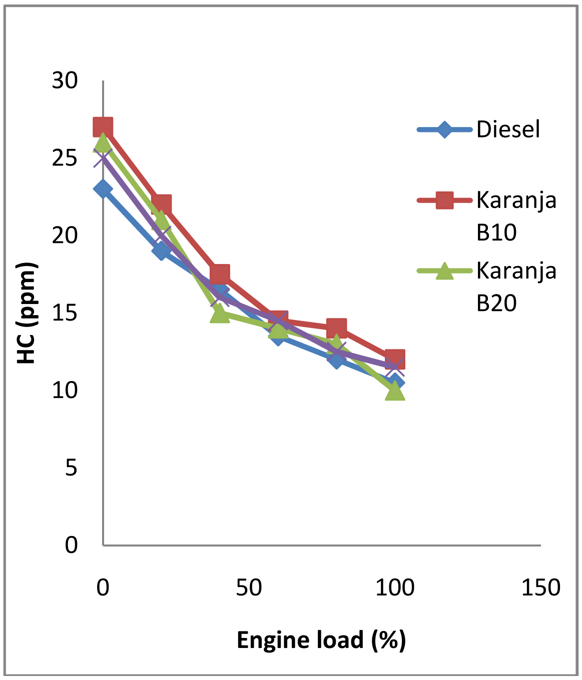


Fig. 7. Hydrocarbons vs. load.

(iv) Oxides of nitrogen

Figure 8 represent the NOx vs load. It is clear from figure the NOx level increases as the load on the engine is increases. Basically, NOx level depends upon higher temperature and oxygen content. It was found that oxygen present in the biodiesel enhance the combustion which results higher peak pressure and temperature rise inside the cylinder. It was found that at higher load in case of B30 the NOx level was 575ppm as compared to neat diesel was 500ppm. Further, it was concluded that in all blends the NOX level was higher as compared to neat diesel.

(v) Smoke density

Figure 9 represent the smoke density vs. load. It is clear from figure as the load on the engine increases the smoke density increases. It was found that at full load in case of B30 the smoke density was 38% as compared to neat diesel was 50%. It was found that in all blends the smoke density was low as compared to neat diesel at all loads.

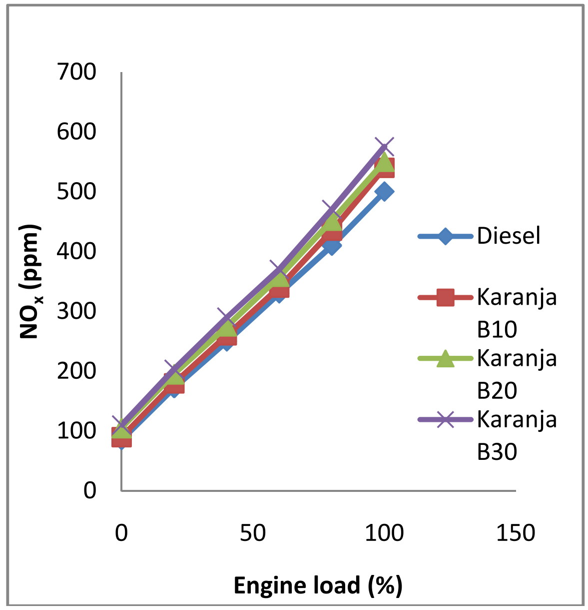


Fig. 8. Oxides of nitrogen vs. load.

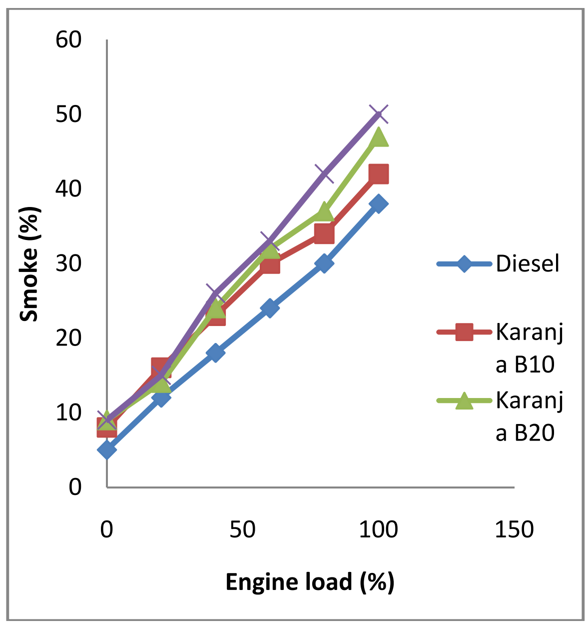


Fig. 9. Smoke density vs. load.

IV. CONCLUSIONS

It was found that karanja is non-edible oil which is available in Rajasthan, India. Karanja oil has potential that can be converted into biodiesel.

The characteristics of karanja biodiesel are found to be closed as per ASTM and BIS standards. Further the engine performance and emissions shows that karanja biodiesel can be used in CI engine without any modification. The experiment results shows blends B10 and B20 shows the same results. They improved BTH, EGT and reduced BSFC. Further they also reduced emissions like CO_2, CO, HC and smoke density and increases NOx level as compared to diesel.

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