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Experimental Investigation of Performance & Emission for the Blend of Diesel & 'Karanja' Bio-Diesel

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Abstract

Due to the increasing demand for fossil fuels and environmental threat, a number of renewable sources of energy have been studied worldwide. An attempt is made to assess the suitability of vegetable oil for diesel engine operation, without any modifications in its existing construction. One of the important factors which influence the performance and emission of diesel engine is fuel injection pressure. The main objective of this study is to investigate the effect of Karanja Biodiesel blended with diesel and investigating performance and emissions characteristics of the engine. By changing the various parameters like Load, Blending Ratio, various performance and emission characteristics will be measured.

Non edible Karanja (Pongamia Pinata) biodiesel blended with diesel were tested for their use as substitute fuels for diesel engines. One of the major objectives of the present study was to experimentally access the practical applications of diesel & karanja biodiesel blend in single cylinder diesel engine used in generating sets, road transport vehicle, and three cylinder diesel engines used for agricultural applications in India.

Keywords: Diesel engine; vegetable oil; Karanja biodiesel, Pongamia Pinata, Blend, Injection Pressure, KME (Karanja Methyle Ester)

Introduction

DIESEL engine has gained the name and fame in serving the society in many ways. Its main attractions are ruggedness in construction, simplicity in operation and ease of maintenance. But due to the shortage of fossil fuel, we may not be able to avail its services for long time. Hence efforts are being made all over the world, to bring out non-conventional fuels for use in diesel engines. The performance and emission characteristics of diesel engines depends on various factors like fuel quantity injected, fuel injection timing, fuel injection pressure, shape of combustion chamber, position and size of injection nozzle hole, fuel spray pattern, air swirl etc.[17]

Materials & Methods

In this work, experimentally studied the performance and emission characteristics of single cylinder direct injection diesel engine using Karanja Biodiesel blended with diesel in various proportions like 10%, 20%, 30% & 40% as a fuel. The Table 2.1 compares some of the important properties of diesel with Karanja Biodiesel.

Table 2.1: Properties of Karanja Biodiesel

	Diesel	**Karanja Biodiesel**
Calorific Value	42010 KJ/Kg	35800 KJ/Kg
Kinematic viscosity	2.87 mm^2/sec	9.6 mm^2/sec
Flash Point (˚C)	52	204
Water Content (%w/v)	0.005	0.17
Sulphur Content (%w/w)	0.02	0.05
Carbon residue (%w/w)	0.1	0.3
Ash content (%w/w)	0.02	0.2

Table 2.2: Technical specifications of the engine

Make	**PowerLite**
Type of engine	Vertical, four stroke, single cylinder, DI diesel engine
Speed	1500 RPM
Bore	102 mm
Stroke	110 mm
Compression ratio	13.5
Method of cooling	Air cooled with radial fan
Rated power	5 KW
Type of starting	Manual
Fuel flow measurement	Burette with digital stop watch
Nozzle injection pressure	200 bar

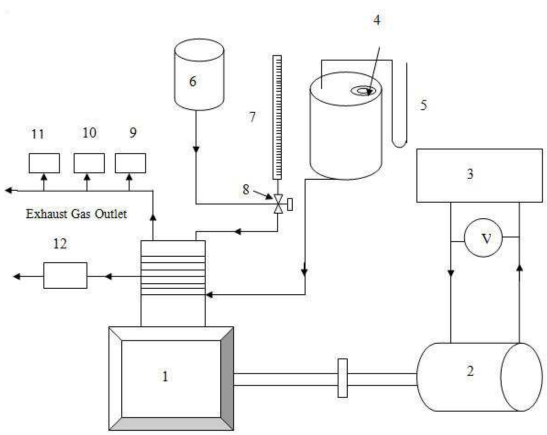

Fig 2.1 Layout of Experimental setup

1. Engine	2. Generator	3. Resistive Load
4. Orifice	5. U-tube manometer	6. Fuel tank
7. Burette	8. Three way valve	9. EGT sensor
10. Exhaust gas analyzer	11. Smoke meter	12. Outlet air temp. sensor

Fig. 2.2 Photographic view of experimental setup

A suitable nomenclature of B0, B10, B20, B30 and B40 (KME 0: D100), (KME 10: D 90), (KME 20: D80), (KME30: D70) and (KME 40: D60) respectively was adopted for identification of fuel. Base line tests were conducted with diesel (KME 0: D100) at fuel injection pressure of 200bar. The independent variables considered for the blends are listed in Table 3.3. The dependent variables of engine performance were power output (PO), brake specific fuel consumption (BSFC), brake specific energy consumption (BSEC), brake thermal efficiency (BThE) and exhaust gas temperature (EGT).

Table 2.3
Independent parameter of karanja Biodiesel and its blends with diesel.

Types of variables studied	Details of variables studied
1. Fuels used	Diesel, Karanja Biodiesel
(a) Diesel	100 % neat
(b) Karanja Bio-diesel- Diesel (v/v), %	B10, B20, B30, B40
2. Load, KW	0,600,1200,1800,2400,3000, 3600,4200 and 4800 KW

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Results And Discussion

*** Performance Parameters**

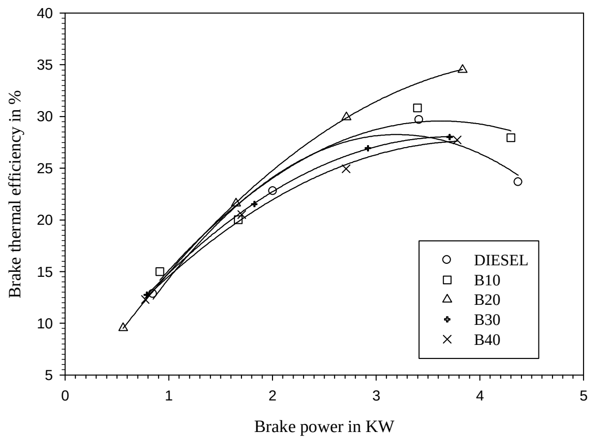

Fig 3.1 Variation of BThE with brake power

Fig.3.1 shows the variation of the brake thermal efficiency with respect to Brake Power for karanja methyl ester-diesel fuel blends. It can be observed from the figure that, B20 shows higher brake thermal efficiencies at all load conditions compared to that of higher blends reported lower values of BTE due to low calorific value and higher fuel consumption. The higher thermal efficiencies may be due to the additional lubricity provided by the fuel blends [18, 19]. Raheman et al. [18] also report higher BTE for the 20% & 40% blends while the higher blends reported lower values of BTE due to low calorific value and higher fuel consumption.

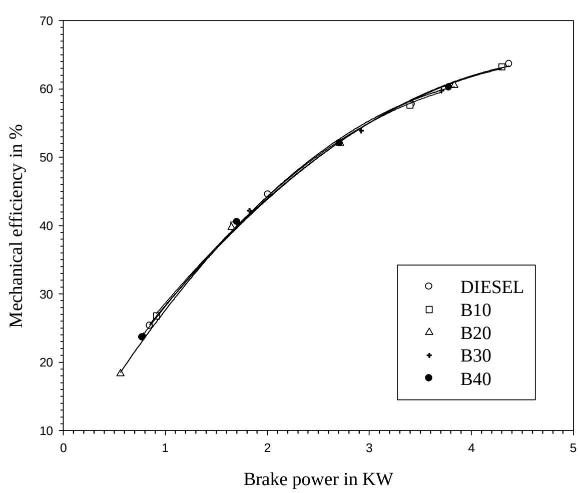

Fig 3.2 Variation of mechanical efficiency with brake power

Fig.3.2 shows the variation of the mechanical efficiency with brake power for various fuel blends. Mechanical efficiency for all the blends at varying load is almost same. Highest mechanical efficiency recorded 63.62 % for base fuel and 63.24 for B10 blend.

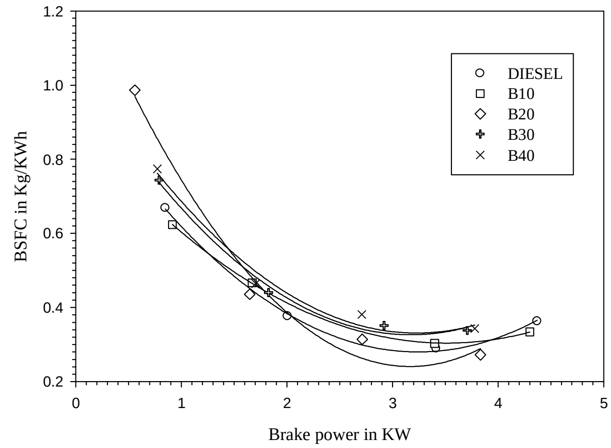

Fig 3.3 Variation of BSFC with brake power

Fig.3.3 shows the variation of the brake specific fuel consumption with brake power. When two different fuels of different heating values are blended together, the fuel consumption may not be reliable, since the heating value and density of the two fuels are different. In such cases, the brake specific fuel consumption (BSFC) will give more reliable value. It can be observed from the figure that the BSFC for B20 is higher as compared to that of diesel fuel and BSFC for B10 is lower as compared to other blends and diesel. The availability of the oxygen in the karanja methyl ester-diesel fuel blend may be the reason for the lower BSFC.

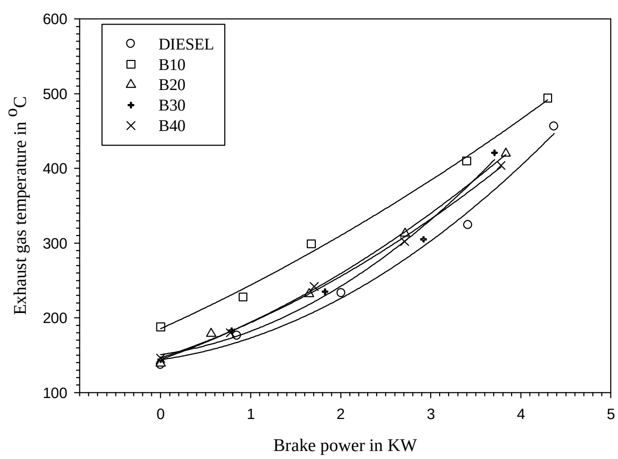

Fig 3.4 Variation of EGT with brake power

The exhaust gas temperature of an engine is an indication of the conversion of heat into work. Fig.6.4 shows the variation of the exhaust gas temperature with brake power for various fuel blends. Exhaust gas temperature for B10 is highest. The exhaust gas temperature rises from 187oC at no load to 402oC at full load for diesel, while for B20 the

exhaust gas temperature rises from 139oC at no load to 420oC at full load.

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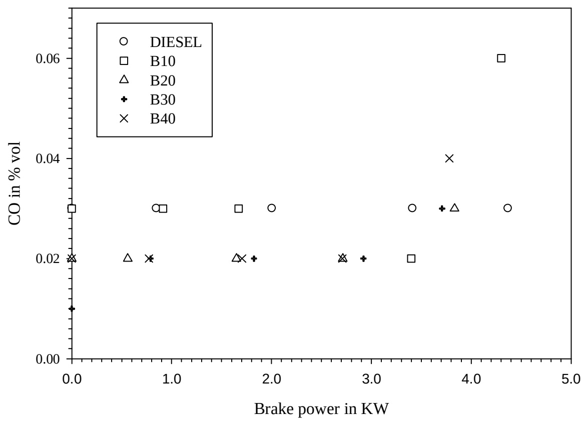

Fig 3.5 Variation of CO with brake power

The emission of carbon monoxide for various blends at different loads can be seen in Fig. 3.5. The emissions are slightly higher for almost all blends. This can be attributed to higher viscosity of the fuel which results in poor atomization & incomplete combustion of the fuel. At higher load, more fuel is consumed which results in relative lowering of the availability of oxygen for the combustion of the fuel, which results in slightly higher carbon monoxide. Lowest CO emission was recorded for B20 blend. R.Prakash et al. [20] report a slight increase in CO emission in engine testing with wood pyrolysis oil blends.

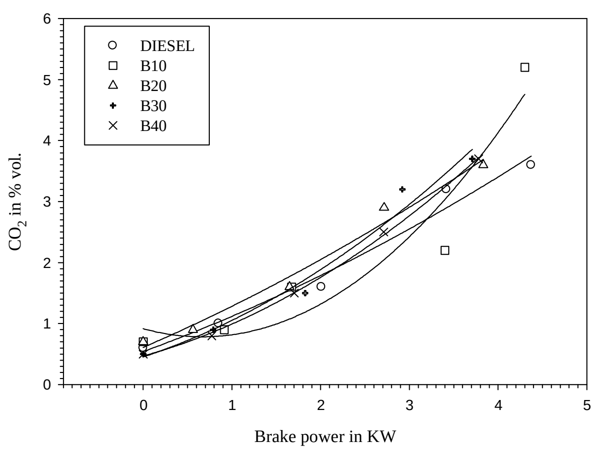

Fig 3.6 Variation of CO_2 with brake power

Fig.3.6 illustrates the variation of carbon dioxide emission for various blends at varying loads. The carbon dioxide emission for the blends is higher than diesel for all loads and blends. Carbon dioxide emission for B10 blend is highest and B20 blend is comparatively lower.

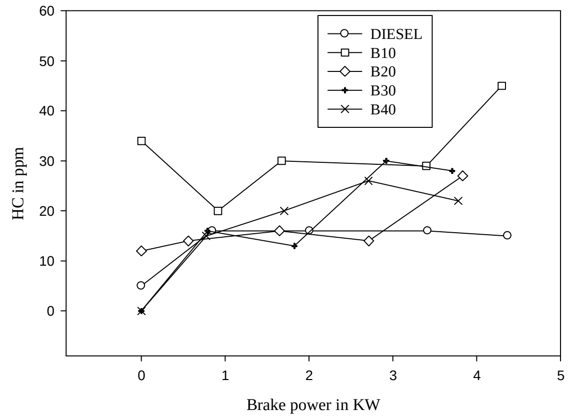

Fig 3.7 Variation of HC with brake power

Fig.3.7 shows the variation of hydrocarbon exhaust emission for different blends at varying loads. Hydrocarbons in exhaust are a result of incomplete burning of the carbon compounds in the fuel. Initially all blends have lower values than diesel owing to higher combustion chamber temperature which helps in cracking and faster burning.

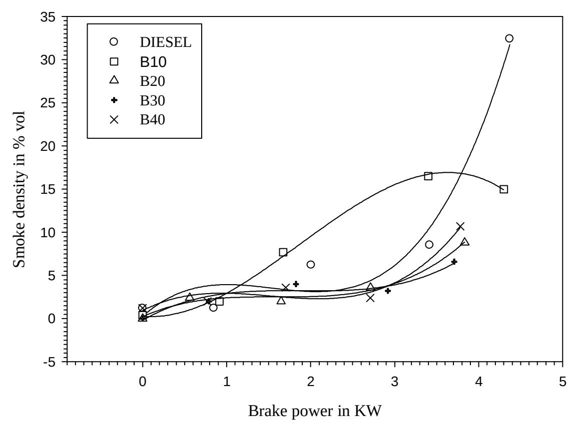

Fig 3.8 Variation of Smoke density with brake power

Fig.3.8 shows the variation of Exhaust Smoke density for different blends at varying loads. From the figure we can observe that B20 and B30 have lower smoke density compared to others. Diesel produces higher smoke at full load.

Result & Discussion

Karanja methyl ester seems to have a potential to use as an alternative fuel in diesel engines. Blending with diesel decreases the viscosity considerably. The following results are made from the experimental study.

1. Present diesel engine runs smoothly with various blends of esterified karanja oil with diesel.

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2. The brake thermal efficiency of the engine with karanja methyl ester-diesel blend was marginally better than with neat diesel fuel.
3. Brake specific fuel consumption is lower for karanja methyl ester-diesel blends than diesel at all loading.
4. The exhaust gas temperature is found to increase with concentration of karanja methyl ester in the fuel blend due to coarse fuel spray formation and delayed combustion.
5. At higher loads, the mechanical efficiency of certain blends is almost equal to that of diesel.
6. The emission characteristics are higher than pure diesel but the B20 has relatively better performance with respect to other blends.
7. **B20 can be accepted as a suitable fuel for use in standard diesel engines** and further studies can be done with certain additives to improve the emission characteristics.
8. Exhaust smoke density is considerably higher with the all blends with reference to the neat diesel.
9. **Maximum efficiency was found to be around 35% for B20.**
10. Engine performance is improved with B20 at injection pressure of 200 bar due to improved atomization. Ratnakar Rao et al. [21] also recorded highest performance and lowest brake specific fuel consumption at 200 bar injection pressure.

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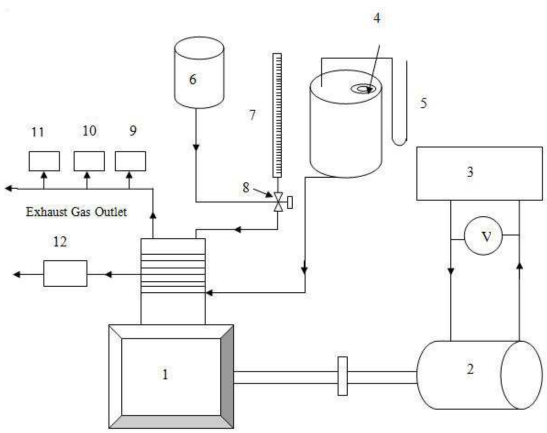

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Table 2.3
Independent parameter of karanja Biodiesel and its blends with diesel.

Types of variables studied	Details of variables studied
1. Fuels used	Diesel, Karanja Biodiesel
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Results And Discussion

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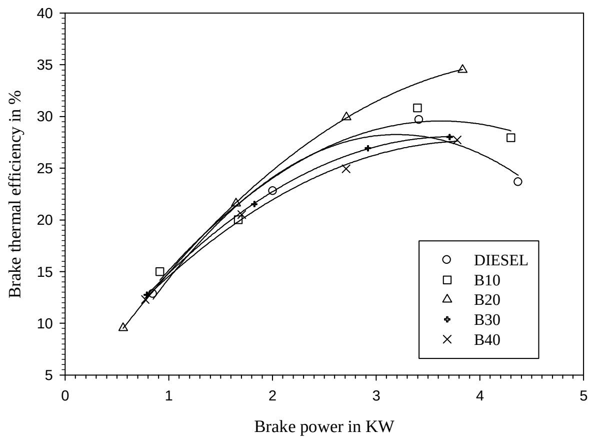

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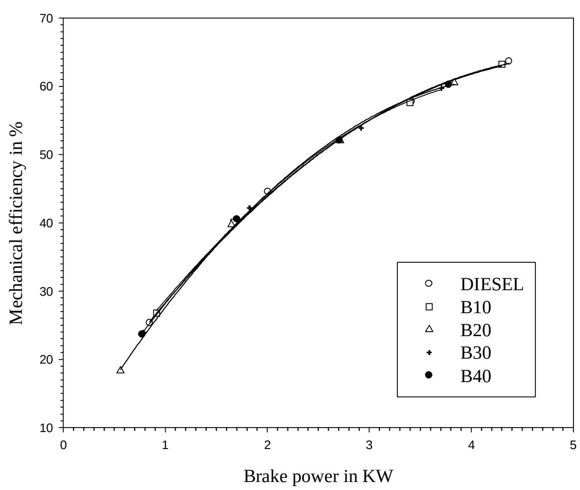

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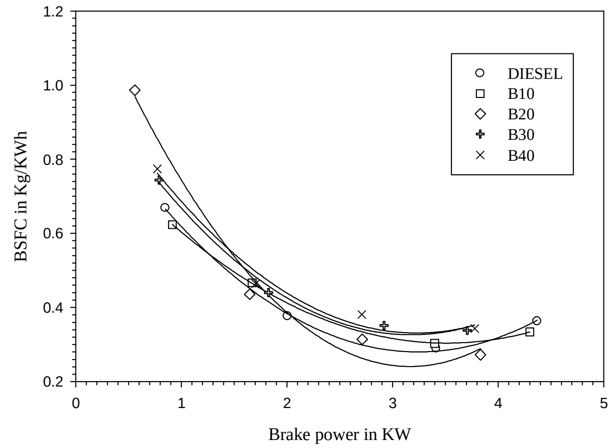

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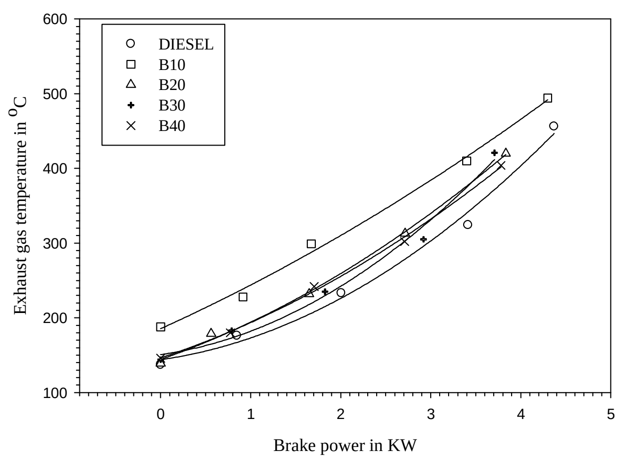

Fig 3.4 Variation of EGT with brake power

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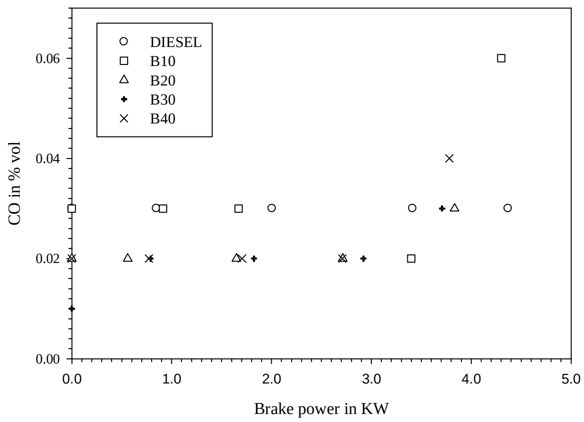

Fig 3.5 Variation of CO with brake power

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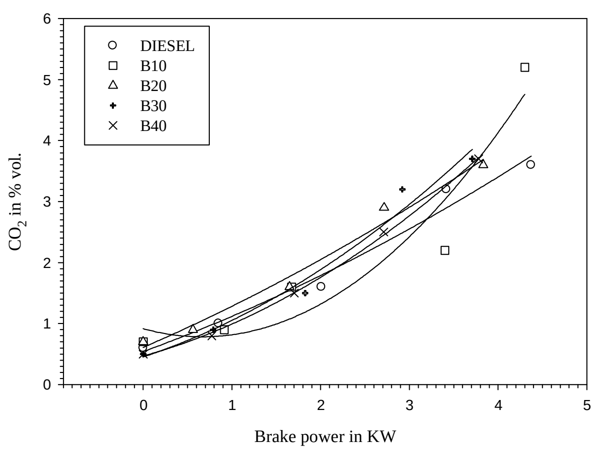

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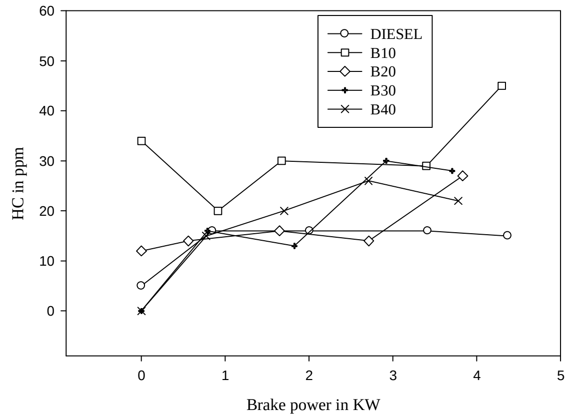

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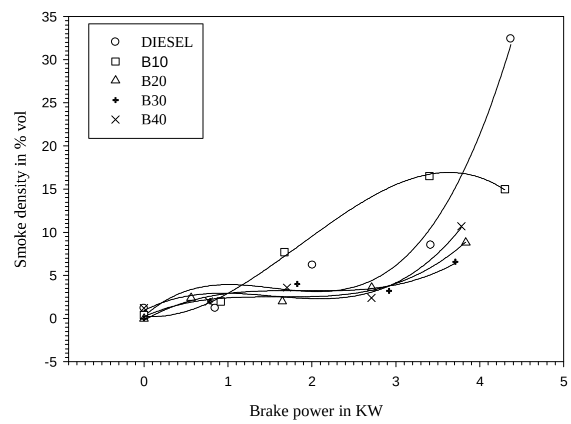

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7. **B20 can be accepted as a suitable fuel for use in standard diesel engines** and further studies can be done with certain additives to improve the emission characteristics.
8. Exhaust smoke density is considerably higher with the all blends with reference to the neat diesel.
9. **Maximum efficiency was found to be around 35% for B20.**
10. Engine performance is improved with B20 at injection pressure of 200 bar due to improved atomization. Ratnakar Rao et al. [21] also recorded highest performance and lowest brake specific fuel consumption at 200 bar injection pressure.

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Experimental Investigation of Performance & Emission for the Blend of Diesel & 'Karanja' Bio-Diesel

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Abstract

Due to the increasing demand for fossil fuels and environmental threat, a number of renewable sources of energy have been studied worldwide. An attempt is made to assess the suitability of vegetable oil for diesel engine operation, without any modifications in its existing construction. One of the important factors which influence the performance and emission of diesel engine is fuel injection pressure. The main objective of this study is to investigate the effect of Karanja Biodiesel blended with diesel and investigating performance and emissions characteristics of the engine. By changing the various parameters like Load, Blending Ratio, various performance and emission characteristics will be measured.

Non edible Karanja (Pongamia Pinata) biodiesel blended with diesel were tested for their use as substitute fuels for diesel engines. One of the major objectives of the present study was to experimentally access the practical applications of diesel & karanja biodiesel blend in single cylinder diesel engine used in generating sets, road transport vehicle, and three cylinder diesel engines used for agricultural applications in India.

Keywords: Diesel engine; vegetable oil; Karanja biodiesel, Pongamia Pinata, Blend, Injection Pressure, KME (Karanja Methyle Ester)

Introduction

DIESEL engine has gained the name and fame in serving the society in many ways. Its main attractions are ruggedness in construction, simplicity in operation and ease of maintenance. But due to the shortage of fossil fuel, we may not be able to avail its services for long time. Hence efforts are being made all over the world, to bring out non-conventional fuels for use in diesel engines. The performance and emission characteristics of diesel engines depends on various factors like fuel quantity injected, fuel injection timing, fuel injection pressure, shape of combustion chamber, position and size of injection nozzle hole, fuel spray pattern, air swirl etc.[17]

Materials & Methods

In this work, experimentally studied the performance and emission characteristics of single cylinder direct injection diesel engine using Karanja Biodiesel blended with diesel in various proportions like 10%, 20%, 30% & 40% as a fuel. The Table 2.1 compares some of the important properties of diesel with Karanja Biodiesel.

Table 2.1: Properties of Karanja Biodiesel

	Diesel	**Karanja Biodiesel**
Calorific Value	42010 KJ/Kg	35800 KJ/Kg
Kinematic viscosity	2.87 mm^2/sec	9.6 mm^2/sec
Flash Point (˚C)	52	204
Water Content (%w/v)	0.005	0.17
Sulphur Content (%w/w)	0.02	0.05
Carbon residue (%w/w)	0.1	0.3
Ash content (%w/w)	0.02	0.2

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Table 2.2: Technical specifications of the engine

Make	**PowerLite**
Type of engine	Vertical, four stroke, single cylinder, DI diesel engine
Speed	1500 RPM
Bore	102 mm
Stroke	110 mm
Compression ratio	13.5
Method of cooling	Air cooled with radial fan
Rated power	5 KW
Type of starting	Manual
Fuel flow measurement	Burette with digital stop watch
Nozzle injection pressure	200 bar

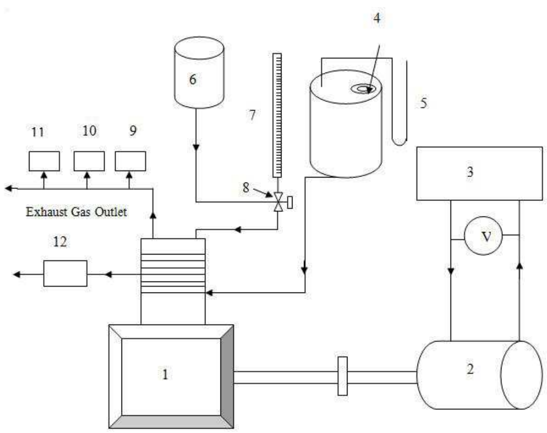

Fig 2.1 Layout of Experimental setup

1. Engine	2. Generator	3. Resistive Load
4. Orifice	5. U-tube manometer	6. Fuel tank
7. Burette	8. Three way valve	9. EGT sensor
10. Exhaust gas analyzer	11. Smoke meter	12. Outlet air temp. sensor

Fig. 2.2 Photographic view of experimental setup

A suitable nomenclature of B0, B10, B20, B30 and B40 (KME 0: D100), (KME 10: D 90), (KME 20: D80), (KME30: D70) and (KME 40: D60) respectively was adopted for identification of fuel. Base line tests were conducted with diesel (KME 0: D100) at fuel injection pressure of 200bar. The independent variables considered for the blends are listed in Table 3.3. The dependent variables of engine performance were power output (PO), brake specific fuel consumption (BSFC), brake specific energy consumption (BSEC), brake thermal efficiency (BThE) and exhaust gas temperature (EGT).

Table 2.3
Independent parameter of karanja Biodiesel and its blends with diesel.

Types of variables studied	Details of variables studied
1. Fuels used	Diesel, Karanja Biodiesel
(a) Diesel	100 % neat
(b) Karanja Bio-diesel- Diesel (v/v), %	B10, B20, B30, B40
2. Load, KW	0,600,1200,1800,2400,3000, 3600,4200 and 4800 KW

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Results And Discussion

*** Performance Parameters**

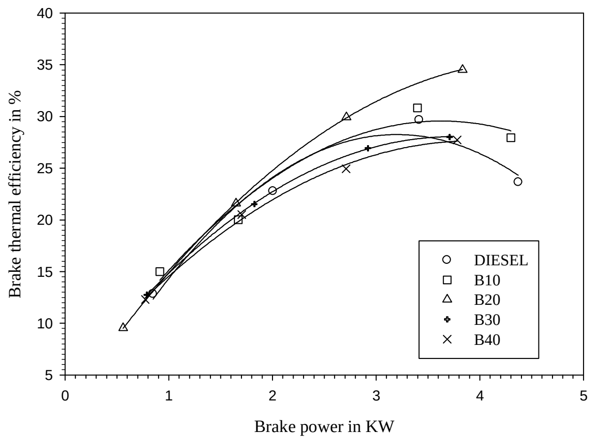

Fig 3.1 Variation of BThE with brake power

Fig.3.1 shows the variation of the brake thermal efficiency with respect to Brake Power for karanja methyl ester-diesel fuel blends. It can be observed from the figure that, B20 shows higher brake thermal efficiencies at all load conditions compared to that of higher blends reported lower values of BTE due to low calorific value and higher fuel consumption. The higher thermal efficiencies may be due to the additional lubricity provided by the fuel blends [18, 19]. Raheman et al. [18] also report higher BTE for the 20% & 40% blends while the higher blends reported lower values of BTE due to low calorific value and higher fuel consumption.

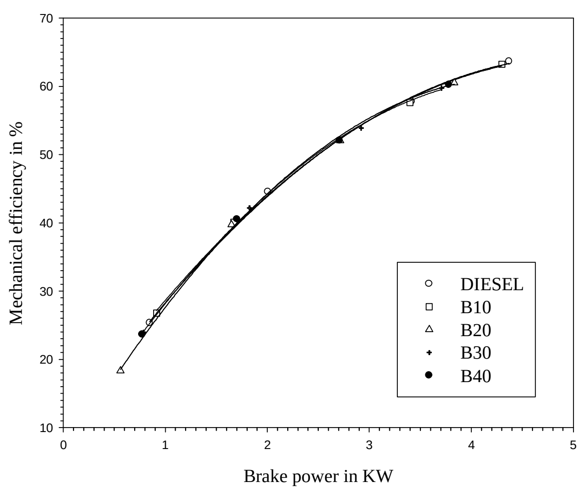

Fig 3.2 Variation of mechanical efficiency with brake power

Fig.3.2 shows the variation of the mechanical efficiency with brake power for various fuel blends. Mechanical efficiency for all the blends at varying load is almost same. Highest mechanical efficiency recorded 63.62 % for base fuel and 63.24 for B10 blend.

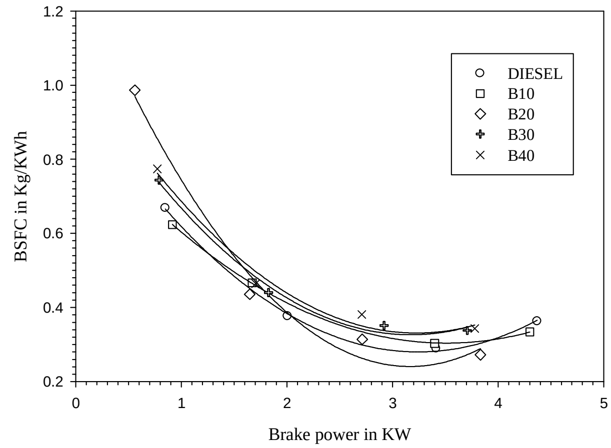

Fig 3.3 Variation of BSFC with brake power

Fig.3.3 shows the variation of the brake specific fuel consumption with brake power. When two different fuels of different heating values are blended together, the fuel consumption may not be reliable, since the heating value and density of the two fuels are different. In such cases, the brake specific fuel consumption (BSFC) will give more reliable value. It can be observed from the figure that the BSFC for B20 is higher as compared to that of diesel fuel and BSFC for B10 is lower as compared to other blends and diesel. The availability of the oxygen in the karanja methyl ester-diesel fuel blend may be the reason for the lower BSFC.

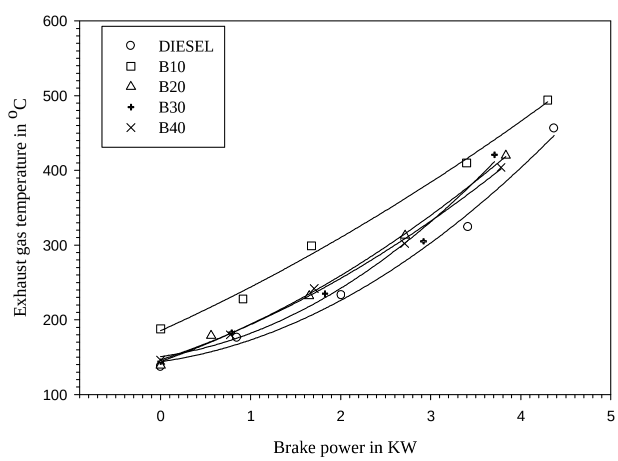

Fig 3.4 Variation of EGT with brake power

The exhaust gas temperature of an engine is an indication of the conversion of heat into work. Fig.6.4 shows the variation of the exhaust gas temperature with brake power for various fuel blends. Exhaust gas temperature for B10 is highest. The exhaust gas temperature rises from 187oC at no load to 402oC at full load for diesel, while for B20 the

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exhaust gas temperature rises from 139oC at no load to 420oC at full load.

*** EMISSION PARAMETERS**

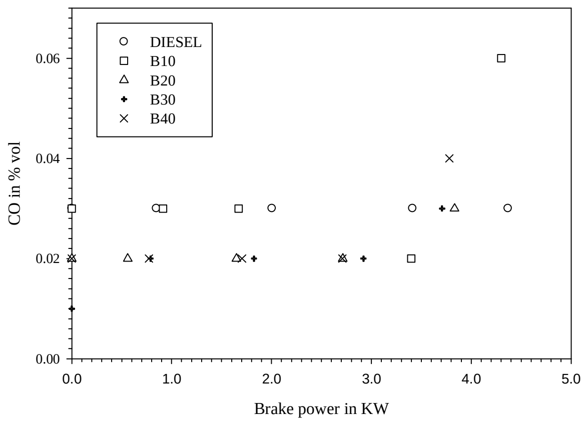

Fig 3.5 Variation of CO with brake power

The emission of carbon monoxide for various blends at different loads can be seen in Fig. 3.5. The emissions are slightly higher for almost all blends. This can be attributed to higher viscosity of the fuel which results in poor atomization & incomplete combustion of the fuel. At higher load, more fuel is consumed which results in relative lowering of the availability of oxygen for the combustion of the fuel, which results in slightly higher carbon monoxide. Lowest CO emission was recorded for B20 blend. R.Prakash et al. [20] report a slight increase in CO emission in engine testing with wood pyrolysis oil blends.

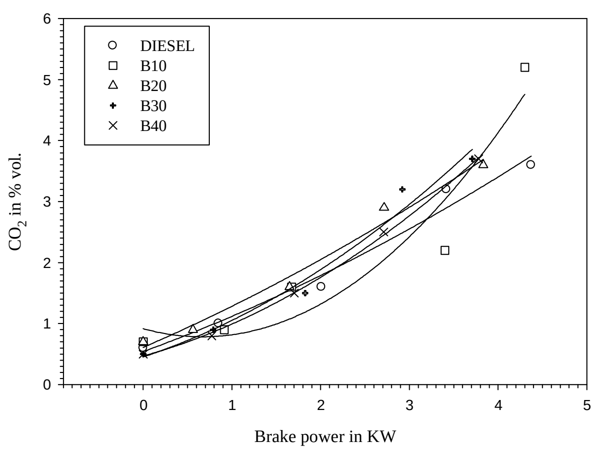

Fig 3.6 Variation of CO_2 with brake power

Fig.3.6 illustrates the variation of carbon dioxide emission for various blends at varying loads. The carbon dioxide emission for the blends is higher than diesel for all loads and blends. Carbon dioxide emission for B10 blend is highest and B20 blend is comparatively lower.

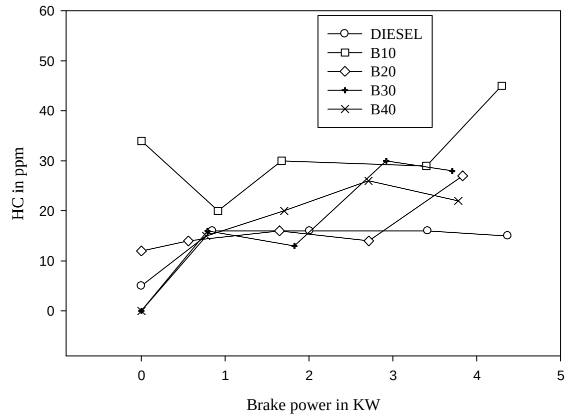

Fig 3.7 Variation of HC with brake power

Fig.3.7 shows the variation of hydrocarbon exhaust emission for different blends at varying loads. Hydrocarbons in exhaust are a result of incomplete burning of the carbon compounds in the fuel. Initially all blends have lower values than diesel owing to higher combustion chamber temperature which helps in cracking and faster burning.

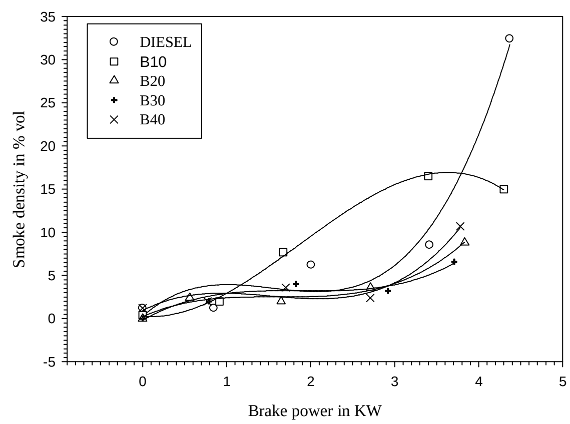

Fig 3.8 Variation of Smoke density with brake power

Fig.3.8 shows the variation of Exhaust Smoke density for different blends at varying loads. From the figure we can observe that B20 and B30 have lower smoke density compared to others. Diesel produces higher smoke at full load.

Result & Discussion

Karanja methyl ester seems to have a potential to use as an alternative fuel in diesel engines. Blending with diesel decreases the viscosity considerably. The following results are made from the experimental study.

1. Present diesel engine runs smoothly with various blends of esterified karanja oil with diesel.

2. The brake thermal efficiency of the engine with karanja methyl ester-diesel blend was marginally better than with neat diesel fuel.
3. Brake specific fuel consumption is lower for karanja methyl ester-diesel blends than diesel at all loading.
4. The exhaust gas temperature is found to increase with concentration of karanja methyl ester in the fuel blend due to coarse fuel spray formation and delayed combustion.
5. At higher loads, the mechanical efficiency of certain blends is almost equal to that of diesel.
6. The emission characteristics are higher than pure diesel but the B20 has relatively better performance with respect to other blends.
7. **B20 can be accepted as a suitable fuel for use in standard diesel engines** and further studies can be done with certain additives to improve the emission characteristics.
8. Exhaust smoke density is considerably higher with the all blends with reference to the neat diesel.
9. **Maximum efficiency was found to be around 35% for B20.**
10. Engine performance is improved with B20 at injection pressure of 200 bar due to improved atomization. Ratnakar Rao et al. [21] also recorded highest performance and lowest brake specific fuel consumption at 200 bar injection pressure.

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