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Original Research Article

PARTIALLY OR FULLY REPLACEMENT OF DIESEL FUEL IN 4-STROKE SINGLE CYLINDER CI ENGINE WITH KARANJA BIODIESEL

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Abstract: A diesel engine was fuelled with diesel and karanja biodiesel blends and its performance and emission characteristics studied. The parameters such as specific fuel consumption (SFC), brake thermal efficiency (BTE) and exhaust emissions of carbon dioxide (CO2), carbon monoxide (CO),and oxides of nitrogen(NOx) were measured and compared with diesel fuel. With 100% karanja (*Pongamia pinnata*) biodiesel, the specific fuel consumption was 340, 304 and 287 g/kWh at 1.5, 2.0 and 2.5kW load conditions while for diesel it is found that 318,287 and 260 g/kWh at 1.5.2.0 and 2.5kW load condition The per cent increase in brake thermal efficiency of engine with karanja biodiesel blends (B15 to B60) ranged from 0.1.1 to 2.3% higher than diesel fuel. . The CO2emission from 100 %biodiesel was slightly higher than that of diesel. The CO reduction and increase in NOx emission by biodiesel were 15to 17 % and 19 to 29 % respectively as compared to diesel at tested load conditions

Keywords: *Pongamia pinnata*, biodiesel, karanja and Fossil fuels

Introduction: Fossil fuels are one of the major sources of energy in the world today. Their popularity can be accounted to easy availability, usability and cost effectiveness. But the limited reserves of fossil fuels are a great concern owing to fast depletion of the reserves due to increase in worldwide demand. Fossil fuels are the major source of atmospheric pollution in world today. So efforts are on to find alternative sources for this depleting energy source. Even though new technologies have come up which have made wind, solar or tidal energy sources easily usable but still they are not so popular due to problems in integration with existing technology and processes. So, efforts are being directed towards finding energy sources which are similar to the present day fuels so that they can be used as direct substitutes. Diesel fuel serves as a major source of energy, mainly in

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the transportation sector. During the World Exhibition in Paris in 1900, Rudolf Diesel was running his engine on 100% peanut oil. In 1911 he stated ''the diesel engine can be fed with vegetable oils and would help considerably in the development of agriculture of the countries, which use it'' . Study and analysis have shown that vegetable oils can be used in diesel engines as they are found to have properties close to diesel fuel It is being considered a breakthrough because of availability of various types of oil seeds in huge quantities . Vegetable oils are renewable in nature and may generate opportunities for rural employment when used on large scale Vegetable oils from crops such as soya bean, peanut, sunflower, rape, coconut, karanja, neem, cotton, mustard, linseed, jatropha and castor have been evaluated in many parts of the world. Non edible oils have been preferred because they don't compete with food reserves. Karanja (*Pongamia pinnata*) is an oil seed-bearing tree, which is non-edible and does not find any other suitable application due to its dark colour and odour . it has high viscosity and density. In this work, different proportions of karanja, viz,15%, 30%, 45%, 60%, and 100% are mixed with 85%, 70%, 55%, 40%,and 0% respectively with diesel fuel on volume basis Energy consumption has been increasing continually since the urbanization. Energy demand rises worldwide, due to the growth in global population, and the fast development of transportation. Transport is the largest consumer of world oil. About 60% of oil production is used for transportation. It is also the second largest emitter of greenhouse gas. About 20% of carbon di-oxide emissions are from the transport part. Now most cars use petrol for the fuel. But fossil fuel is limited and uneven distribute. Furthermore traditional fuels have more pollution to environment. Nowadays, energy security, climate change and rising of global energy demand are gradually entering the attention of public. In order to reduce oil dependency and develop sustainable transport, many countries plan to replace conventional fuels with alternative fuels in the future

Karanja (*pongamia pinnata*): Karanja (*pongamia pinnata*) is a medium sized tree, is found almost throughout India. Karanja tree is wonderful tree almost like neem tree. The common name of the oil is Karanja(*pongamia pinnata*) Seed Oil and the botanical name is Pongamia glabra of Leguminaceae family. Karanja is widely distributed in tropical Asia and it is nonedible oil of Indian origin. It is mainly found in the Western Ghats in India, northern Australia, Fiji and in some regions of Eastern Asia. .The plant is also said to be highly tolerant to salinity and can be grown in various soil textures viz. stony, sandy and clayey. Karanja (*pongamia pinnata*) can grow in humid as well as subtropical environments with annual rainfall ranging between 500 and 2450 mm. This is one of the reasons for wide availability of this plant species. The tree bears green pods which after some 10 months change to a tan colour. The pods are flat to elliptic, 5-8 cm long and contain 1 or 2 kidney shaped brownish red kernels. The yield of kernels per tree is reported between 7 and 24 kg. .The kernels are white and covered by a thin reddish skin. The composition of typical air dried kernels is: Moisture 19%, Oil 27.5%, and Protein 17.4%. The present production of karanja (*pongamia pinnata*) oil approximately is 201 million tons per annum. The time needed by the tree to mature ranges from 4 to 7 years and depending on the size of the tree the yield of kernels per tree is between 7 and 24 kg. India is a tropical country and offers most suitable climate for the growth of karanja(*pongamia pinnata*) tree. It is found in abundance in rural areas and forests of entire India, especially in eastern India and Western Ghats. Fig.1 shows the close view of seeds of karanja (*pongamia pinnata*). The seeds are crushed in expeller to get the oil. A view of raw oil obtained by crushing the seeds has been given in Fig.2 As the trees of karanja (*pongamia pinnata*) is naturally found in forests, there are so far no reports on adverse effects of karanja (*pongamia pinnata*) on fauna, flora, humans or even on environment but that is a different area of research. Karanja oil has been reported to contain furan flavones, furanoflavonols, chromenoflavones, flavones and furanodiketones which make the oil nonedible and hence further encourages its application for biodiesel production.

Fig 1.Seed of karanja

Fig 2. Oil expelled from karanja seed

Physical- chemical properties of *pongamia pinnata* crude oil-

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Exporter & Manufacturers : Natural Essential Oils, Spice Oils, Aroma Theraphy Oils & Allied Products

CERTIFICATE OF ANALYSIS

Product	Karanja Oil "KE"
Lot No.	K – 9865 – KE - 2016
Manufacturing Date	September - 2016
Best Before	September - 2018
Appearance	Pale yellow liquid.
Colour	Almost colourless
Odour	Characteristic odd odor.
Botanical Name	Pongamia pinnata

PHYSICO-CHEMICAL PROPERTIES:-

Specific Gravity	0.925 – 0.940 @ 20°C
Palmitic Acid:	3.7 – 7.9
Unsaponifiables:	3.0 %
Oleic Acid:	44.5 – 71.3
Cloud Point	8.3 °C
Flash Point:	134 °C

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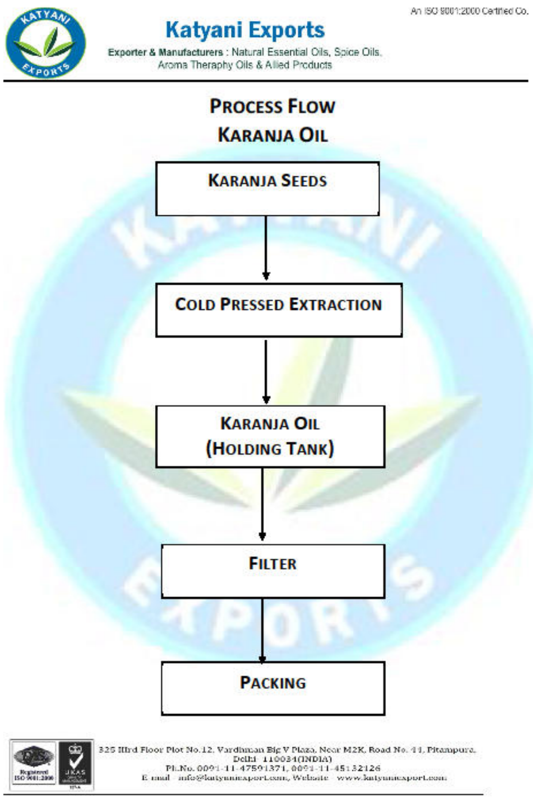
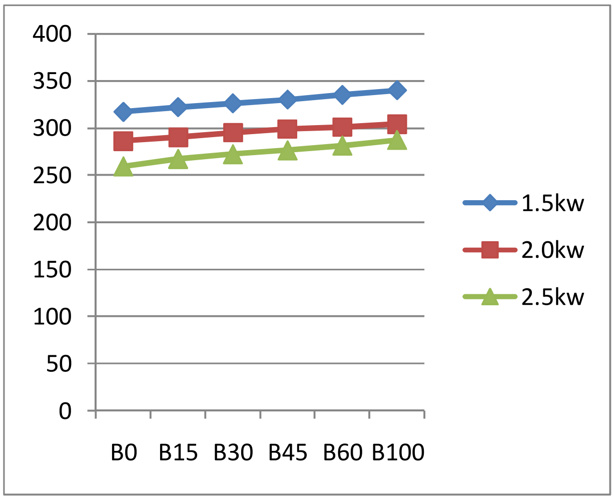
Method for production of biodiesel:



Result: i. Specific fuel consumption: The specific fuel consumption for karanja(*pongamia pinnata*) biodiesel alone (B100) were found to be 340, 304 and 287 g/kWh at 1.5, 2.0 and 2.5 kW load conditions respectively. The increase in SFC of biodiesel blends (B15 to B60) ranged from 1 to 6, 1 to 5 and 1 to 8% higher than that of diesel at 1.5, 2.0 and 2.5 kW loads . The percent increase in SFC increased with decreased quantity of diesel in the blended fuels. The reason for increase in fuel consumption is due to higher density and lower heating value of the biodiesel as compared with diesel.

Table1: values of specific fuel consumption at different blend and different load

Blend\load	1.5kw	2.0kw	2.5kw
B0	317	286	259
B15	322	290	267
B30	326	295	272
B45	330	299	276
B60	335	301	281
B100	340	304	287



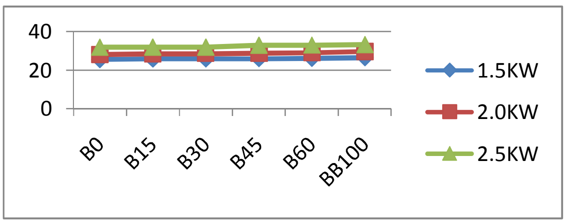
y axis-SFC in g/kwhr x axis- biodiesel blend

Graph 1: Variation of SFC with biodiesel blend at different load

ii. Brake thermal efficiency: The brake thermal efficiency of the engine when operating with karanja(*pongamia pinnata*) biodiesel alone (B100) were 26.59, 29.78 and 31.56% at three load conditions tested . Maximum brake thermal efficiency of 31.56% was noted for biodiesel, which was 31.05% for diesel. The BTE of biodiesels was found to be 1 to 6% higher than that of diesel fuel and there was no significant difference between the karanja (*pongamia pinnata*) biodiesel and its blended fuel efficiencies.

Table 2: Values of Brake thermal efficiency at different blend and different load

Blend\load	1.5kw	2.0kw	2.5kw
B0	25.5	28	32
B15	25.8	28.3	32.05
B30	25.9	28.5	32.08
B45	26	28.7	33
B60	26.2	29	33.1
B100	26.59	29.78	33.4



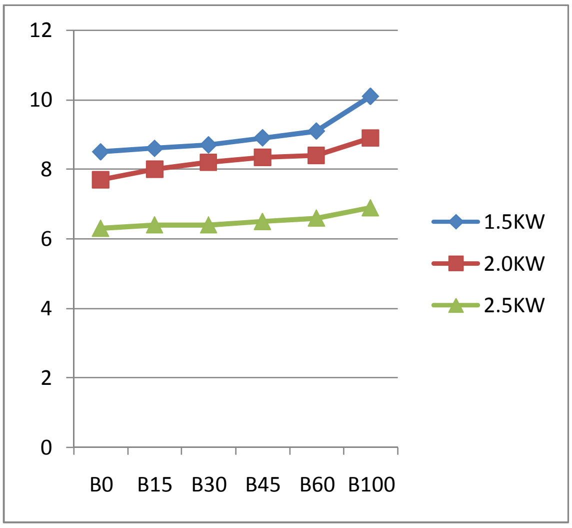
y axis-BTE in % , x axis- biodiesel blend

Graph-2: Variation of BTE with biodiesel blend at different load

iii. Carbon di-oxide emission: The carbon di-oxide emission at 1.5, 2.0 and 2.5 kW loads was noted as 10.1, 8.9 and 6.9% for karanja biodiesel whereas that of diesel fuel was 8.5, 7.7 and 6.3 %. For the biodiesel blended (B15 to B60) fuels, carbon di-oxide emission emission increased from 1 to 7, 4 to 16 and 2 to 5% at 1.5, 2.0 and 2.5 kW load conditions. For 1.5, 2.0 and 2.5 kW loading conditions

Table 3: values of carbon di-oxide emission at different blend and different load

Blend\load	1.5kw	2.0kw	2.5kw
B0	8.5	7.7	6.3
B15	8.6	8	6.4
B30	8.7	8.2	6.4
B45	8.9	8.35	6.5
B60	9.1	8.4	6.6
B100	10.1	8.9	6.9



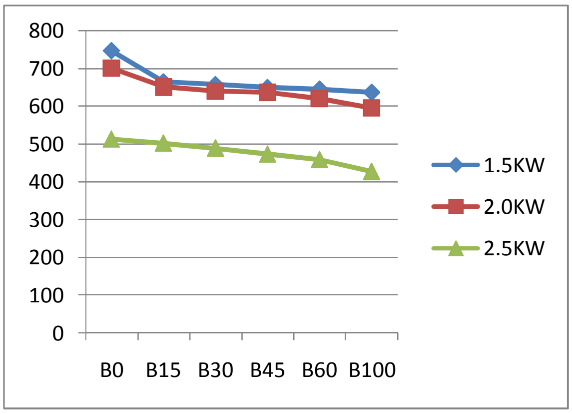
y axis-CO_2 emission in % by volume
x axis- biodiesel blend

Graph-3: Variation of CO_2 emission with biodiesel blend at different load

iv. carbon monoxide emission: The carbon mono oxide emission was noted as 637, 596 and 428 ppm for karanja biodiesel whereas it was 748, 701 and 514 ppm for diesel fuel. For the biodiesel blended (B15 to B60) fuels, carbon mono oxide emission decreased from 665 to 648, 651 to 420 and 503 to 460 ppm at 1.5, 2.0 and 2.5 kW load conditions.

Table 4: values of carbon mono oxide emission at different blend and different load

Blend\load	1.5kw	2.0kw	2.5kw
B0	748	701	514
B15	665	651	503
B30	658	640	490
B45	650	637	474
B60	646	620	460
B100	637	596	428



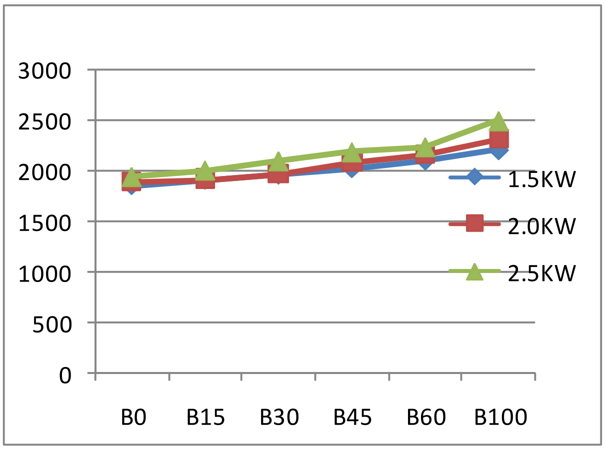
y axis-CO emission in ppm
x axis- biodiesel blend

Graph-4: Variation of CO_2 emission with biodiesel blend at different load

V. Oxides of Nitrogen : The oxides of nitrogen emissions increased with increase in biodiesel quantity in the blends and also the NOx emission from the biodiesel alone was found to be higher than diesel. Oxides of nitrogen emissions under selected tested load conditions were noted as 2202, 2313 and 2487 ppm for karanja(*pongamia pinnata*) biodiesel, whereas it was 1850, 1888 and 1935 ppm for diesel fuel. For the biodiesel blended (B15 to B60) fuels, the NOx emission increased from 1905 to 2100, 1915 to 2166 and 2000 to 2230 ppm at 1.5, 2.0 and 2.5 kW load conditions. It is seen that with increase in the quantity of biodiesel in the blends, there was an increase in oxides of nitrogen emission. Several reasons associated for the increased oxide of nitrogen emission from karanja (*pongamia pinnata*)biodiesel, i) formation of oxides of nitrogen depends upon the oxygen availability and combustion temperatures and ii) During combustion of biodiesel in the engine, the oxygen present in fuel oxidizes the nitrogen, which led increasing oxide of nitrogen emissions .

Table 5: values of oxides of nitrogen emission at different blend and different load

Blend\load	1.5kw	2.0kw	2.5kw
B0	1850	1890	1935
B15	1905	1915	2000
B30	1955	1962	2090
B45	2020	2090	2180
B60	2100	2160	2230
B100	2202	2313	2487



Y axis-SFC in g/kwhr,   x axis- biodiesel blend

Graph-5: Variation of CO_2 emission with biodiesel blend at different load

Conclusions: Performance and emission characteristics were conducted on karanja (*pongamia pinnata*) biodiesel fuelled diesel engine at an injection pressure 240 bar, the following conclusions are drawn based on the test results: Karanja (*pongamia pinnata*) biodiesel alone, the specific fuel consumption was 8, 6 and 10% higher than that of diesel at 1.5, 2.0 and 2.5 kW loads. The corresponding BTE were found to be slightly higher than that of diesel fuel at tested load conditions and there was no significant difference between the biodiesel and its blended fuels efficiencies. The carbon di oxide emission from the biodiesel fuelled engine was slightly higher than that of diesel fuel. The carbon monoxide reduction by biodiesel was 15, 15 and 17% respectively at 1.5, 2.0 and 2.5 kW load conditions. The oxides of nitrogen emission from biodiesel was 19 to 29 % higher than that of the diesel fuel at the tested three load condition

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