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Emission and Performance of Diesel Engine Using Karanja BioDiesel - A Critical Review

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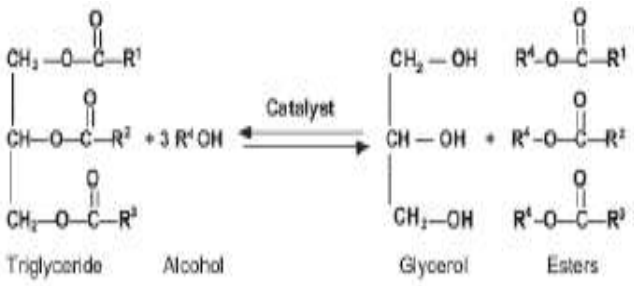
Abstract

This paper presents a brief review on the Karanja (Pongamia Pinnata) biodiesel emission and its performance characteristics as Diesel engine fuel. Biodiesel is the name of a clean burning alternative fuel produced from domestic, renewable resources. It contains no petroleum, but it can be blended at any level with Diesel to create a biodiesel blend. It can be used in Diesel engines with no modifications. It is simple to use biodegradable, non toxic and essentially free of sulphur and aromatics. Based on the research reports, it is concluded that vegetable oils, either chemically altered or blended with Diesel to prevent the engine failure. It was reported that the combustion characteristics of biodiesel are similar to Diesel. Power out put of engine was found to be equivalent to that of Diesel fuel. CO, NO_x and HC are with in maximum limits that safer use as an alternative fuel.

Key words: ***Karanja biodiesel, Diesel engine, emissions and performance.***

1. Introduction: During last decade India has maintained a high growth rate in accepting the improved technological challenges in global scenario. India ranks 6th in the world in terms of energy demand accounting for 3.5% of world commercial energy demand in 2001. The energy demand is expected to grow at 4.8%. The demand of Diesel is projected to grow from 39.81 million metric tons in 2001-02 to 52.32 million metric tons in 2006-07 at 5.5% per annum. Also due to gradual depletion of the world petroleum reserve, rising petroleum prices, increasing threat to the environment from exhaust emission and global warming have generated an intense international intrest in developing alternative non petroleum fuels [1].The purpose of transesterification process is to decrease the oil viscosity. Major problems of vegetable oil as biodiesel are their high viscosity and low volatility, which causes improper combustion in C.I.engines. The conversion of the vegetable oil as a C.I.engine fuel can be done by transesterification process. This process reduces the viscosity to a value comparable to that of Diesel and hence improves combustion.



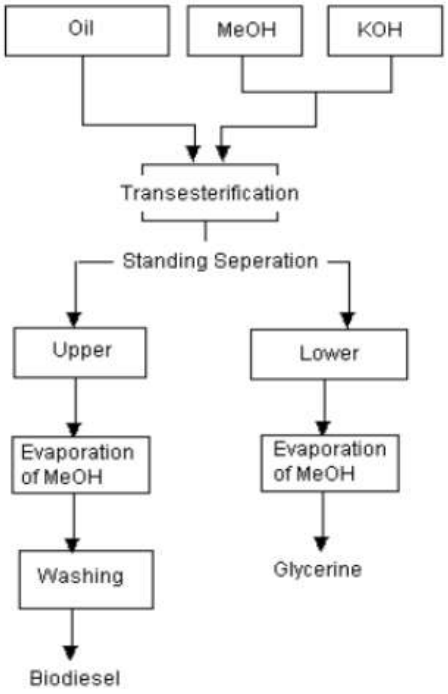


Figure-1: Bio diesel Process

Untreated Karanja oil is mixed with a mixture of anhydrous methanol in the presence of NaOH as catalyst. The mixture is maintained at a temperature little below 65^0C, the B.P. of methanol and continuously stirred the mixture for around 3 hours. After completion of stirring, the mixture is allowed to settle down for 24 hours. The layer of glycerol settled at the bottom is carefully taken out and the upper layer is the ester of Karanja oil which is collected separately [1].Karmee and Chada [2] prepared biodiesel from Pongamia Pinnata by transesterification in the presence of Potassium Hydroxide as catalyst.

2. Emissions from Karanja BioDiesel:

Biodiesel mainly emits Carbon monoxide, Carbon dioxide, Oxides of Nitrogen, Sulphur oxides and Smoke. A brief review has made about these pollutants emitted from bioDiesel. Sudipta Choudhury, Dr.P.K.Bose[1] carried experiments on Kirloskar make vertical single cylinder, D.I.Diesel engine. The emissions as well as engine performance were studied at different engine load at maximum power. It is noticed that for B20 blend the maximum & minimum CO produced is 0.42 g/KW-hr & 0.05 g/KW-hr, which is much less than mentioned in EURO-IV norms (Maximum 1.5 g/KW-hr).It is an indication of the complete combustion of biodiesel being an oxygenated fuel. The shorter ignition delay associated with biodiesel higher Cetane number could also reduce the over mixed fuel which is the primary source of UBHC. For B20 the maximum & minimum HC produced is 0.02 g/KW-hr & 0.004 g/KW-hr, which is around same as that is mentioned in EURO-IV norms (Maximum 0.02 g/KW-hr).For B20 blend the percentage increase of CO_2 for maximum & minimum load is 3.8& 3.75. This increase in percentage is may be due to complete combustion of the fuel. For Diesel engine the minimum & maximum exhaust temperature is 120^0 C & 260^0 C, where as for B20, it is found to be 81^0 C & 216^0 C. The injection timing advancement associated with these effects could be partially responsible for the increase in NOx emissions. For B20 blend the maximum & minimum NO_x produced is 0.04 g/KW-hr & 0.002 g/KW-hr, which is much less than mentioned in EURO-IV norms (Maximum 3.5 g/KW-hr).

Raheman and Phadatare [3] tested Karanja Methyl Ester (KME) and its blends with Diesel from 20% to 80% by volume in a single cylinder D.I. Diesel engine and found that an effective reduction of smoke density,CO & NOx emissions. Also the B20 blend shows the similar result with narrow range of variation with respect to mineral Diesel. There is no such variation of exhaust gas temperature using Diesel & KME because of heat loss to the exhaust is nearer to be same.

Suryawanshi & Deshpande [4] studied the effect of EGR and retardation injection timing on C.I. engine fuelled with KME. It is reported that NOx emissions were reduced with injection timing retardation and EGR compared to standard conditions. Nagarhalli M.V, Nandedkar V.M. et.al [5] have been carried out experimental work on emission & performance characteristics of Karanja biodiesel and its blends in a C.I. engine. The results of experimental investigation with biodiesel blends were compared with mineral Diesel. The results indicate that the CO emissions

were slightly higher for B20 & B40 blends. HC emissions decreased from 12.8 % for B20 & 2.85% for B40 compared to Diesel at full load. Depending on load, the NOx emissions decreased by 39% for B20 & 28% for B40 at full load. Baiju et.al [6] studied a comparative evaluation of Diesel engine characteristics using KOME. It is reported that smoke formation is lesser. The reason is the complete combustion of KOME due to the presence of more oxygen in the biodiesel for all loads. Smoke emission from ethyl ester is more than that of methyl ester. At lower loads, CO emissions not much varied for all fuels. At full load, B20 KOEE emits more CO than methyl esters due to enrichment of oxygen which results in better combustion with biodiesel. NOx emissions of biodiesel blends and pure biodiesel are higher than Diesel at part loads. At higher loads, Diesel is emitting more NOx than biodiesel fuels. Ethyl esters are emitting more NO_x than methyl esters. Chennakesava Reddy et.al [7] have been performed an experimental work on Potential of a Low

Heat Rejection (LHR) Diesel engine with crude Pongamia oil. It is reported that in LHR engine preheating of vegetable oils decreased smoke levels & NOx levels with the advancing of the injection timing and increase of injection pressure. Anand Kumar Pande et.al [8], the effects of pure Karanja biodiesel fuel on performance, emission & engine wear of a 118 KW,6 cylinder, CIDI engine have been investigated & compared with the base line Diesel fuel. The observations are CO emission decreased by 80% when Diesel fuel is replaced with pure Karanja oil biodiesel fuel at full load condition. The UHC decreases by 42% at full load condition with pure Karanja oil biodiesel fuel & NO_x emission increase by 10% with pure Karanja oil biodiesel fuel in comparison with Diesel fuel at full load condition.

Kamal Kishore Khatri et.al [9], on the basis of the observations & results of the experimental investigations on a single cylinder, 4 stroke constant speed stationary, water cooled C.I. engine run on Karanja-Diesel blend and Diesel oil at different injection timings, reported that slightly more smoke emissions are observed with Karanja-Diesel blend compared to Diesel over entire load range mainly due to poor atomization of Karanja oil. However the smoke level for K40 at optimum timing is less than the smoke level of K40 at standard timing.

Nagarhalli et.al [10] studied the emission and performance characteristics of the blend of Karanja biodiesel and Diesel by varying three injection pressure of 190 bar, 200 bar and 210 bar and concluded that the HC emissions decreased for B20 & B40 blends by 15-25% at an injection pressure of 190 bar. NOx emissions showed a drop of 24% for B20 blend & 16% for B40 blend. HC emissions at 200 bar injection pressure decreased by up to 3% for B20 & B40 where as NO_x decreased by 30-39% in comparison with Diesel. At an injection pressure of 210 bar, HC emissions were unchanged for B20 blend and decreased by 18 % for B40 blend where as NOx showed an increasing trend (8-18%).

B.K.Venkanna et.al [11] investigated Pongamia Pinnata linn oil Diesel blend on the single cylinder, DI Diesel engine and tests were conducted for the entire load range(0 to 100%)i.e.0 to 5 H.P.) at constant speed of 1500 RPM. and reported that least CO & HC emissions were observed at 275 bar & 250 bar respectively and this is better than neat Diesel at standard injection pressure of 200 bar.

Nanthagopal K et.al [12] on the basis of the experimental investigations on a single cylinder, 4 stroke, DI, bowl in piston combustion chamber Diesel engine run on KOME. It is noticed that CO, HC & Smoke emissions are lower for biodiesel blends as compared to Diesel. However emissions of NOx are found to be higher for biodiesel blends.

3. Performance of Karanja BioDiesel:

The performance parameters such as Power out put, Specific fuel consumption, Brake thermal efficiency of Karanja Biodiesel had been evaluated by different researchers after experimental studies are reported in this section.

Sudipta Choudhury, Dr.P.K.Bose [1] reported that the break thermal efficiency is increased due to reduced heat loss with increased in load. The maximum efficiency obtained is 33.74% (B25) & 33.54 %(B20).BSFC reduces with increase in load. The reverse trend in the BSFC may be due to increase in bioDiesel percentage ensuring lower calorific value of fuel. Raheman and Phadatare [3] reported that both Torque & Brake power increased with increase in load. This is due to increase in fuel consumption with increase in load. The torque & B.P. produced in case of B20 & B40 is 0.8 to 7.4% lower than Diesel. The maximum brake thermal efficiency obtained as 26.79%& 26.19% for of B20 & B40 respectively, which were more than that of Diesel (24.62%). Nagarhalli M.V, Nandedkar V.M. et.al [5] reported that the brake specific energy consumption value increased by 7% for B20 & 1.9% for B40 at full load. Hence a blend of 40% biodiesel and 60% Diesel (B40) is recommended. There is no significant change in efficiency. Chennakesava Reddy et. al [7] observed that preheating of the vegetable oils improved performance when compared with normal vegetable oils in both versions of the engine. Improvement in the performance is observed with the advancing of the injection timing and with the increase of injection pressure with the vegetable oil operation on both versions of the engine. Anand Kumar Pande et.al [8] reported that the Brake power of the engine slightly decreases when Diesel engine is fueled with pure Karanja oil biodiesel fuel. Kamal Kishore Khatri et.al [9] experimentally found that, for Karanja Diesel blend (K40) injection timing of 19^0 BTDC is found to be the optimum injection timing, as highest brake thermal efficiency, lowest BSFC are observed over the entire load range at this injection timing.Dipak Patil, Dr.Rachayya, et.al [13] studied the performance analysis of 4 cylinder, 4 stroke Diesel engine using Karanja biodiesel & reported that Brake power, Brake thermal efficiency, Mechanical efficiency and time for fuel consumption is higher at constant speed & also at variable speed & load condition for 20% & 40% biodiesel blends with Diesel fuel.

Sagar Pramodrao Kadu et.al [14],on the basis of the observations & the results of the experimental investigations on a computerized single cylinder 4 stroke CI engine powered by neat Karanja oil at different fuel inlet temperatures, reported that at higher speed there is no significant difference in BSFC when the engine is operated with preheated and unheated vegetable oil fuels. The Karanja oil fuel produced the same brake thermal efficiency at high speed & low speed of the engine and slightly deviating in the mid of the speed range studied. The heated fuel showed a marginal decrease in brake thermal efficiency as compared to Diesel fuel operation. Engine power increases with speed to a maximum value at an engine speed of 3500 RPM. At speeds more than 3500 RPM the power produced is slightly higher than that of Diesel fuel.

N.Stalinn& H.J.Prabhu [15] concluded that Brake power is higher for the dual fuel combustions from B5 to B30 than Diesel. In case of B40, the B.P. is more or les equal to that of Diesel. For the dual fuel combinations from B50 to B100, the B.P. is less than that of Diesel. As the load increases, BSFC decreases to the minimum of at 70% load and then increases for all the fuel samples tested. This can be correlated that B.P. increases as the load increases. As the load increases, brake thermal efficiency increases up to 70% load and then decreases for all the fuel samples tested. The low brake thermal efficiency for B60, B80 and B100 may be due to the lower HHV and the increase in fuel consumption.

Y.C.Bhatt & M.K.Verma[16] concluded that the fuel temperature and injection pressure has significant role on engine performance parameters. Power out put and brake thermal efficiency decrease with the increase in concentration of KME in Diesel & increased with the increase in the injection pressure and fuel temperature. The BSFC & BSEC increased with the increase in concentration of KME in Diesel & decreased with the increase

in injection pressure and fuel temperature. S.S.Karhale et al.[17] tested the blend of Karanja biodiesel & Diesel with two variable injection pressure of 180 & 245 Kgf/cm^2 and temperature of 30,50 & 70^{0}C and concluded that engine starting is normal with KME and its blend with Diesel. Injection pressure & fuel temperature were found to be significant effects on engine performance parameters. The power out put decreases with increase in the concentration of KME in Diesel and increased with increase in injection pressure and fuel temperature. R.K. Singh & Saswat Rath [18] have been carried out experimental work on 4 stroke, single cylinder DI Diesel engine for performance analysis of blends of KME. It is noticed that the brake thermal efficiency of the engine with KME-Diesel blend is marginally better than with neat Diesel fuel. BSEC is lower for KME-Diesel blends than Diesel at all loading.

Conclusions:

Biodiesel is an alternative to Diesel as a fuel in Diesel engine. The engine performance of Karanja bio-diesel has been compared to that of Diesel. It is found from the literature review that the emission characteristics of bio-diesel are better than Diesel except NO_x emission. CO, UBHC and particulate matter emissions were found to significantly decrease with bio diesel and its blends due to more complete combustion caused by higher oxygen content. Hence based on engine emission studies i.e., CO, NO_x & HC, it is concluded that the parameters studied were with in the maximum limits and are safe to use as an alternate fuel.

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