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VEGETABLE DERIVED BIODIESEL FUEL AS AN ALTERNATE FUEL FOR DIESEL ENGINES– A REVIEW

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ABSTRACT

Due to depletion of petroleum resources, environmental degradation and stringent regulations for diesel engine emission norms, there is a growing interest in the developments of possible alternative sources for conventional fuels. Lot of research work is going on to improve the performance and emissions of a diesel engine running on alternative sources. Biodiesel derived from vegetable oils is one of the attractive alternative fuels for diesel fuels as they are renewable, domestically grown, producing low emissions and biodegradable.Transesterification method is the mostly used route for the conversion of vegetable oils into methyl esters. This paper reviews the utilization of various vegetable derived biodiesel blends in a diesel engine as alternate fuels. Biodiesel can be made from various renewable sources. Utilization of biodiesel in a diesel engine as an alternate fuel is a major step towards improving the diesel engine performance and lowering the engine out emissions.

Key words: Biodiesel, Diesel fuel, Emission, Performance and Transesterification.

INTRODUCTION

Chemically biodiesel is a mixture of methyl esters with long chain fatty acids and is made from non-toxic, biological sources such as vegetable oils, animal fats and used cooking oils etc. With the depletion of petroleum sources, emission of greenhouse gases is increasingevery day and research is being geared to search for alternate fuels.Biodiesel made from vegetable oil have emerged as a promising alternate fuel for diesel fuel due to its renewable nature, better ignition quality, comparable energy content and higher safety without any engine modifications. Biodiesel can be used alone, or blended with petrol/diesel in any proportions.Thus, biodiesel provides numerous benefits in terms of environmental protection and economic development. The main problem associated with vegetable oil is its high viscosity and low volatilitywhich results in slow combustion. Several methods are used to reduce the viscosity of vegetable oils such as pyrolysis, micro-emulsification, dilution and transesterification. Transesterification is the most widely used method for producing biodiesel using alkali, strong acid or enzymes as catalyst and methyl or ethyl alcohol as solvent. A large variety of plants that produce non-edible oils can be considered for biodiesel production such as Madhuca Indica, Jatropha curcas, Pongamia pinnata, Soybean, rapeseed, palm, sunflower and Neem etc., are easily available in developing countries and are very economical comparable to edible oils. The main objective of the paper is to assess the benefits and limitations of different biodiesel fuels and its blend on performance and emissions of a diesel engine.

PROPERTIES

Biodiesel has promising lubricating properties and cetane ratings compared to low sulphur diesel fuels. The calorific value of biodiesel is about 37.27 MJ/kg. Variations in biodiesel energy density are more dependent on the feedstock used than the production process. It has been claimed biodiesel gives better lubricity and more complete combustion thus increasing the engine energy output. The colour of biodiesel ranges from golden and dark brown, depending on the production method. It is slightly miscible with water, has a high boiling point and low vapour pressure. The flash point of biodiesel is significantly higher than that of diesel or gasoline. Biodiesel has a density of 0.88 g/cm³, higher than petrol/diesel. Biodiesel contains virtually no sulphur and it is often used as an additive to low sulphur diesel fuel to aid with lubrication.

Major Non-Edible Tree Seeds

Bio diesel from mahua seed is found abundantly in tribal areas. Mahua is a non-traditional& non edible oil also known as Indian butter tree. Mahua seed contain 30-40 percent fatty oil called mahua oil**. I**n India the mahua plant is found in the statesof Bihar, Orissa, Jharkhand, Chhattisgarh, Madhya Pradesh and Tamilnadu. Jatropha curcus is a drought-resistant perennial, growing well in marginal/poor soil. It produces seeds with an oil content of around 37%. The oil can be combusted as fuel without being refined. It burns with clear smoke-free flame, tested successfully as fuel for simple diesel engine. It is found to be growing in many parts of the country, rugged in nature and can survive with minimum inputs and easy to propagate.

The botanical name of Karanja seed Oil and is Pongamia glabra of Leguminaceae family. Pongamia is widelydistributed in tropical Asia and it is nonedible oil of Indian origin. It is found mainly in the Western Ghats in India, northern Australia, Fiji and in some regions of Eastern Asia. Karanja can grow in humid as well as subtropical environments. Neem (Mellia azadirachta) is of Meliaceae family. It is growing in tropical and semi tropical regions. Neem is a fast growing tree and can reach upto a height of 15–20 to 35–40 m. It bears an ovoid

fruit, 2cm by 1cm and each seed contains one kernel. Neem oil can be used as Soaps, medicinal and insecticide. Neem oil can be processed into non bitter edible oil with 50% oleic acid and 15% linoleum acid.

Soybean is a very versatile grain that gives rise to products widely used by agro-chemical industry and food industry. Besides is a raw material for extraction of oil for bio fuel production. Soybean has about 25% of oil content in grain. The largest producers of soybeans are: United States, Brazil, Argentina, China and India. Sunflower (*Helianthus annuus L*) a member of the *compoitea* family is an important oil seed cropworldwide yielding approximately 40-50% oil.In wide range of climatic conditions ofIndia, sunflower crops fits well in the local intercropping systems and in all seasons. A huge potential exists to increase the domestic production of sunflower oil in India. Sunflower oil iswidely used in foods for cooking and frying purposes, is also gaining attention as a feedstock for biodieselproduction.

Oil palm, an oleaginous tropical plant, has the highest oil productivity per unit of land onearth. In terms of its usage, palm oil has various uses as a food (oils, margarines, bread,mayonnaise, feeds, ice cream, cookies etc.) in industry (soap, lubricants, detergents, plastics,cosmetics, rubber etc.) in steel making, the textile industry, pharmacology etc.

Literature Survey

Devan et al. (2009) studied the significance of bio-fuels for the complete replacement of diesel fuel in a diesel engine. They have chosen the Bio-fuels namely, methyl ester of paradise oil (Me) and eucalyptus oil (Eu)in the form of blends. Various proportions of paradise oil and eucalyptus oil are prepared on a volume basis to study the performance and emission characteristics of single cylinder diesel engine. The results showed 49% reduction in smoke, 34.5% reduction in HC emissions and 37% reduction in CO emissions for the Me50–Eu50 blend with a 2.7% increase in NOx emission at full load. There was a 2.4% increase in brake thermal efficiency for the Me50–Eu50 blend at full load. They observed that the combustion characteristics of Me50–Eu50 blend are comparable with that of diesel fuel.

Sahoo et al.(2009) tested non-edible jatropha, Karanja and polanga oil based methyl esters blended with conventional diesel having sulphur content less than 10 mg/kg. Ten fuel blends (Diesel, B20, B50 and B100) were tested for their use as substitute fuel for a water-cooled three cylinder tractor engine. Test data were generated under full/part throttle position for different engine speeds (1200, 1800 and 2200 rev/min). Change in exhaust emissions (Smoke, CO, HC, NO_x, and PM) were also analysed for determining the optimum test fuel at various operating conditions. The maximum increase in power is observed for 50% jatropha biodiesel and diesel blend at rated speed. Brake specific fuel consumptions for all the biodiesel blends with diesel increases with blends and decreases with speed. There is a reduction in smoke for all the biodiesel and their blends when compared with diesel. Smoke emission reduces with blends and speeds during full throttle performance test.

Anbumani et al. (2010) studied the feasibility of using two edible plant oils mustard and neem as diesel substitute and a comparative study on their combustion characteristics on a C.I. engine were made. Oils were esterified (butyl esters) before blending with pure diesel in the ratio of 10:90, 15:85, 20:80, and 25:75 by volume. Pure diesel was used as control. Studies have revealed that on blending vegetable oils with diesel a remarkable improvement in their physical and chemical properties was observed. Cetane number came to be very close to pure diesel. Engine was run at different loads (0, 4, 8, 12, 16, and 20 kg) at a constant speed (1500 rpm) separately on each blend and also on pure diesel. Results have indicated that engine run at 20% blend of oils showed a closer performance to pure diesel. However, mustard oil at 20% blend with diesel gave best performance as compared to neem oil blends in terms of low smoke intensity, emission of HC and NOx. All the parameters tested viz., total fuel consumption, specific energy consumption; specific fuel consumption, brake thermal efficiency and cylindrical peak pressure were improved. These studies have revealed that both the oils at 20% blend with diesel can be used as a diesel substitute.

Ozsezen et al. (2011) studied the potentiality of two fuels namely waste palm oil methyl esters (WPOME) and canola oil methyl esters (COME) in a diesel engine. It was observed from the study that when the test engine was fuelled with WPOME or COME, the maximum power output dropped slightly, while the brake specific fuel consumption (bsfc) was 10% and 9% higher than that of diesel. Although both biodiesels have approximately the same energy content, slight variations in the cylinder gas pressure dispersions were seen due to the small differences in bsfc values and fuel properties. The cylinder gas pressures of both biodiesels varied smoothly. The premixed combustion phase for both biodiesels carried out at more wide range of crank angle, and the ignition delay and the SOI timing reduced by using WPOME and COME compared to the diesel fuel. The shorter ignition delay and earlier fuel injection affected the start of combustion, combustion duration, peak cylinder pressure and temperature, thus reducing unburned Hydro carbon, Carbon monoxide and smoke opacity, but increasing Nitrogen oxide (NO_x) formation.

Altun (2011) investigated experimentally the performance and exhaust emissions of a direct injection diesel engine using 2 biodiesel fuels with promising economic perspective, one obtained from inedible animal tallow and the other from waste cooking oils. Inedible animal tallow, which is obtained from a mixture of slaughtered cattle and sheep fats collected from a local slaughterhouse during meat preparation process, was transesterified using methyl alcohol and an alkaline catalyst to produce the inedible animal tallow methyl ester. Biodiesel from waste cooking oil was produced from waste cooking oils and methyl alcohol via a transesterification reaction, and provided by a commercial biodiesel producer. In order to investigate the performance and exhaust emissions, the experiments were conducted at different engine speeds under the full load condition of the engine. The brake torque with diesel fuel was higher than those with both of the biodiesels, and also the biodiesel from inedible animal tallow showed slightly lower brake torque than waste cooking oil biodiesel. The BSFCs for both of the biodiesels were higher than that of diesel fuel, and also the BSFCs for both of the biodiesels were comparable to each other. Both inedible animal tallow and waste cooking oil biodiesels produced less CO emissions than diesel fuel. The comparison of decreases in CO emissions between inedible animal tallow and waste cooking oil biodiesels indicates that inedible animal tallow is more effective than waste cooking oil. NO_x emissions were higher with waste cooking oil and lower with inedible animal tallow when compared with those of diesel fuel. NO_x emissions were highest with waste cooking oil biodiesel.

Elango et al. (2011)studied the combustion characteristics, engine performance and exhaust emissions of blends of transesterified jatropha oil with diesel fuel in a diesel engine. The variation in the peak pressures is not significant but an increase in the ignition delay of about 6 to 9 deg. in crank angle was observed for the blends when compared to diesel. The specific fuel consumption is slightly higher for B20 but closer to diesel among all the blends. When the concentration of jatropha oil in diesel is more than 30% by volume there is an appreciable increase in the specific fuel consumption. The smoke opacity is found to be higher than diesel for all blends, but blends up to 20% substantially reduce CO_2 emissions with a marginal decrease in brake thermal efficiency. A maximum brake thermal efficiency of 29.4% was achieved for B20 while for diesel it was 30.9% for the same power output. However the decrease in brake thermal efficiency can be effectively improved by adding alcohol based additives. Experimental investigations show that blending of jatropha methyl esters up to 20% by volume with diesel for use in an unmodified Diesel engine is viable.

Celikten (2012) examined the usability of methyl ester of rapeseed oil and hazelnut produced abundant in Turkey. The Turkey's economy is mainly dependent on agriculture and the country provides almost all petroleum demand through imports, the evaluation of vegetable alternative engine fuels is of great importance. In this study, Experiments were carried out in a four-cylinder, four-stroke, 46 kW, direct injection diesel engine. A comparison of diesel fuel, the rapeseed oil methyl ester and the hazelnut oil methyl ester blends was made from the engine performance and emissions point of view. Engine performance and emission tests were carried out with 4 different fuel that 100% diesel (SD), 50% rapeseed oil methyl ester and 50% diesel (B1), 50% hazelnut oil methyl ester and %50 diesel (B2), 25% rapeseed oil methyl ester, 25% rapeseed oil methyl ester and 50% diesel (B3). Highest engine performance and lowest specific fuel consumption were obtained with SD fuel. But the use of biodiesel led to reduction in CO and smoke emissions accompanying with the imperceptible torque loss. As the rapeseed methyl ester rate increased in the blend, smoke and CO emissions decreased, NO_x and CO_2 emissions increased. With the use of B1 fuel, NO_x emissions increased up to 7.2%.

Ghosh et al. (2012) analyzed and compared the performance and emission characteristics of biodiesel and its blends with diesel fuel. A four stroke water cooled single cylinder direct injection diesel engine was run successfully using Pongamia oil and its blends (B25, B50, B75 and B100) as fuel. The following conclusions are made with respect to the experimental results. At full load condition brake thermal efficiency of the biodiesel blends were marginally lower than the neat diesel fuel. Specific fuel consumption for B25 blend was close to neat diesel fuel at full load condition. Exhaust gas temperature of biodiesel blends were higher than neat diesel fuel at all load conditions. The smoke density of the Pongamia oil blends was higher than the neat diesel fuel at all load conditions. There was 24% reduction of hydrocarbon of B100 than neat diesel at full load condition. There was 4% reduction of CO emission of B25 than neat diesel at full load condition. There was 2% reduction of NO_x of B25 blend than neat diesel at full load condition. Pongamia oil, a biodiesel is renewable and biodegradable. Its B25 blend performance and emission characteristics are closer to diesel. So it can be used as substitute of diesel without modification of the engine hardware.

Dodiya et al. (2013) tested the performance and emissions of a diesel engine running on linseed oil blends with diesel fuel in a diesel engine. Non edible Vegetable oil like linseed oil is blended with diesel in various proportions like 10%, 20%, 30% and 40%, and find optimum blend which gives improved engine performance and emission characteristics.They have concluded the following results. This type of blend of fuel can directly use in the engine without modification in the engine. As the linseed oil concentration increased in the diesel fuel the break

thermal efficiency is decreased. The break thermal efficiency in the L30D70 blends which is optimum compare to other blend. As the concentration of linseed oil increased the specific fuel consumption (SFC) also increased. But the SFC is in the L30D70 blend which is optimum compared to other blend. Mechanical efficiency is high in L40D60 blend as compared to the conventional diesel fuel. Fuel consumption of the diesel fuel is less as compared to the other blend. In the L30D70 blend the fuel consumption is optimum compare to other blend. As concentration of linseed Oil increased the fuel consumption is also increased. As the percentage of linseed oil increased in the diesel fuel the CO emission decreased as compared to the diesel. In the L30D70 blend the CO emission is less as compared to the diesel fuel. As the percentage of linseed oil increased in the diesel fuel the HC emission is also increased as compared to the diesel. As the percentage of linseed oil increase the NO_x emission is increased slightly as compared to the diesel fuel.

Mohanraj et al.(2013) investigated the operating characteristics of a single-cylinder four-stroke variable compression ratio engine fuelled with esterified tamanu oil blends. The suitability of esterified Tamanu oil produced from pinnai oil by transesterification process has been studied in variable compression ratio engine. Experiment has been conducted at various loads like 0 kg, 3 kg, 6 kg, 9 kg, and 12 kg with engine speed of 1500 rpm and at compression ratio varies from 14:1 to 18:1. The impact of compression ratio on fuel consumption, combustion parameters, and exhaust gas emissions is investigated. In order to vary the compression ratio, the clearance volume is changed geometrically by tilting cylinder block arrangement. The performance characteristics like specific fuel consumption, brake power, mean effective pressure, brake thermal efficiencies, and exhaust gas temperature are analysed for Tamanu oil in the variable compression ratio engine. The emission characteristics like hydrocarbon, nitrogen oxides, carbon monoxide, and carbon dioxide emissions are also measured for Tamanu oil in the same engine. The effect of intake valve closing event-timing modulation on effective compression ratio was also investigated. The motivation behind this analysis was to fix the effective compression ratio for biodiesel.

Janarthanam et al. (2013) investigated the emissions and performance of aKirloskar Direct Injection 4-stroke Diesel engine, single cylinder air-cooled, 4.4 kW, compression ratio 17.5:1 and at constant speed of 1500 rpm,. The Injection pressure, blend percentage, and various loading were used as input parameters. Emissions and Performance like NOx, CO, HC, CO_2, and Break specific fuel consumption, Brake thermal efficiency were considered as output parameters. Methyl Esters of refined vegetable oils was transesterified with sodium meth oxide as catalyst before blending with diesel. A 3-hole nozzle was used to inject the fuel. The Emission results were studied using AVL gas analyzer. In this study the experimental data showed that the break thermal efficiency of the Refined Palmolein of the biodiesel was marginally higher than diesel fuel. It was also observed that CO, HC, CO_2& NO_x are less in Refined Palmolein than Refined Corn and Refined Sunflower oil. Also specific fuel consumption of the refined Palmolein oil biodiesel is reduced by 28.57% compared to pure diesel fuel.

Agarwal et al. (2013)tested the blends of Karanja oil in a diesel engine. In their experimental study, they have investigated the performance, emission and combustion characteristics of Karanja oil blends (K10, K20, K50 and K100) with mineral diesel in unheated conditions in a direct injection CI engine at different engine loads and constant engine speed (1500 rpm) baseline data from mineral diesel. Analysis of performance parameters such as brake specific fuel consumption (BSFC), thermal efficiency, and exhaust gas temperature; mass emissions of various gaseous pollutant species; combustion parameters such as in-cylinder pressure rise, instantaneous heat release and cumulative heat release etc. were carried out. Detailed combustion analysis revealed that the combustion duration increased significantly even with smaller concentration of Karanja oil in the fuel blend. HC, CO and Smoke emissions were found to decrease for 20–50% karanja oil content in the fuel blends.

Nantha Gopal et al. (2014) investigated the emissions and combustion characteristics of a CI engine fuelled with diesel and biodiesel blends.They have compared the performance, emission and combustion characteristics of a direct injection compression ignition engine fuelled with waste cooking oil methyl esters (WCME) and their blends with diesel fuel. They have observed the following results: The diesel engine can perform satisfactorily on biodiesel and its blends with the diesel fuel without any engine modifications.The Specific energy consumption increases with change in percentage of biodiesel in the blends due to the lower heating value of biodiesel. It is also observed that there is significant reduction in carbon monoxide (CO), unburnt hydrocarbons (UBHC) and smoke emissions for biodiesel and its blends compared to diesel fuel. However, nitrogen oxides (NOx) emission of WCME biodiesel is marginally higher than petroleum diesel. They have concluded that waste cooking oil (WCO) biodiesel could replace thediesel in order to help in controlling air pollution, encouraging the collection and recycling of waste cooking oil to producebiodiesel and reduce the dependency on fossil fuel resources to some extent without sacrificing the engine performance.

Md. Saiful Islam et al. (2014) published a paper on emission and performance of diesel engine using castor biodiesel. The acid based catalyzed transesterification system was used to produce castor biodiesel and the highest yield of 82.5% was obtained under the optimized condition. The smoke emission test revealed that B40 (Biodiesel

blend with 40% biodiesel and 60% diesel) had the least black smoke compared to the conventional diesel. Diesel engine performance test indicated that the specific fuel consumption of biodiesel blend was increased sufficiently when the blending ratio was optimized. Thus, the reduction in exhaust emission and reduction in brake –specific fuel consumption made the blends of caster seed oil (B20) a suitable alternative fuel for diesel and could help in controlling air pollution.

Saifullah et al. (2014) presented an overview on the potentiality of microalgae with particular emphasis as a sustainable renewable energy source for biodiesel. Microalgae have a number of characteristics that allow the production concepts of biodiesel which are significantly more sustainable than their alternatives. It is possible to produce microalgae biodiesel to satisfy the fast growing energy demand within the restraints of land and water resources. Microalgae farming can be coupled with flue gas CO_2 mitigation and wastewater treatment. Microalgae can produce a large variety of novel by products. Microalgae biodiesel is not yet economically viable enough to replace petroleum based fuels or compete with other renewable energy technologies such as wind, solar, geothermal and other forms of Bioenergy. Despite their high potential both in terms of productivity and sustainability, most algae based biofuel concepts still require significant investment to become commercially viable.

CONCLUSION

Vegetable oils can be easily produced from plantsgrown in waste lands like Jatropha, Mahua, and Neem. These are clean burning, renewable, non-toxic, biodegradable and eco-friendly. This paper reviews the performance, combustion characteristics and exhaust emissions of a diesel engine fuelled with various biodiesel blended fuels. The following conclusions were drawn based on the review. The thermal efficiency of few biodiesel blended fuels is marginally increased compared to pure diesel fuel. With the use of biodiesel blended fuels specific fuel consumption is increased due to the reduction in heating value of biodiesel compared to diesel fuel.The majority of literatures agree that NO_xemissions are increased with the addition of biodiesel blends to diesel fuel except few biodiesel fuels. This increase is mainly due to higher oxygen content for biodiesel. The use of biodiesel favors to reduce the carbon monoxide emissions compared with diesel fuel due to the higher oxygen content. It is predominant viewpoint that HC emissions reduce when the blends of biodiesel is fuelled with diesel engine instead of diesel. This reduction is mainly due to the higher oxygen content of biodiesel. It is observed clearly that smoke emission is reduced by using biodiesel blends which tend to reduce the particulate matter emissions of biodiesel. The study suggests that it is possible to convert vegetable oils into biodiesel which has similar properties to diesel and can be used as fuel in existing unmodified diesel engines without any difficulty and also replace the diesel fuel in the near future.

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