Study of performance characteristics of diesel engine using alternative fuels

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ABSTRACT

Diesel engines are the main source of transportation, power generation and agricultural applications and etc. But due to fast depletion of world petroleum reserves and the impact of environmental pollution, there is an urgent need to search for suitable alternate fuels for diesel engines. The main alternative fuel sources are vegetable oil, biomass and alcohols. Biodiesel derived from vegetable oils is one of the attractive alternative fuels for diesel fuels as they are renewable, domestically grown producing low emissions. Biodiesel can be used in the existing engine without any modifications. Biodiesel is made entirely from vegetable sources, it does not contain any sulfur, aromatic hydrocarbons, metals or crude oil residues. Biodiesel is an oxygenated fuel, emissions of carbon monoxide and soot tend to reduce. The use of biodiesel can extend the life of diesel engines because it is more lubricating than petroleum diesel fuel. The objective of this project is to get a better knowledge about the various vegetable oils which are available in the market and to have a detailed idea to do some experimental work in the future.

KEY WORDS: Biodiesel, Vegetable oils, alternative fuels

1. INTRODUCTION

Biodiesel is a mixture of methyl ester with long chain fatty acid. It is a fuel equivalent of petro diesel with the exception of its derivation from biological sources fuel equivalent of petro diesel with the exception of its derivation from biological sources. With the depletion of petroleum source emission of greenhouse gases is increasing day by day and research is being geared to search for alternate fuels. Both non-toxic and renewable, biodiesel which comes from plants and animals. The major source of biodiesel is soybean oil, but other oils include rapeseed, canola, palm, cottonseed, sunflower, and peanut. All of which can be replenished through farming and recycling. Biodiesel can even be made from recycled cooking grease! Although biodiesel can be used in its pure form, it is usually blended with standard diesel fuel. Blends are indicated by the abbreviation Bxx, where xx is the percentage of biodiesel in the mixture. Much attention has been focused on the thought of it one day replacing fossil fuels as the world's primary transport energy source. Biodiesel is safe and can be used in diesel engines with few or no modifications needed. 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 volatility which result is slow combustion. Transesterification is 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 such as madhuca, indica, jatropha, soybean, palm, sun flower and neem etc. are used as production of biodiesel and used to developing the country.

Properties: The physical and chemical properties of biodiesel are determined by the compositional profiles. Biodiesel properties can vary substantially from one feedstock to the next. The properties of individual fuels can vary because of its considerable oxygen content (typically 11%), biodiesel has lower carbon and hydrogen contents compared to diesel fuel, resulting in about a 10% lower mass energy content. However, due to biodiesel's higher fuel density, its volumetric energy content is only about 5– 6% lower than petroleum diesel. Typically, biodiesel has somewhat higher molecular weight than petroleum diesel, which is reflected in slightly higher distillation temperatures. Consisting mainly of straight chain esters, most biodiesel fuels have excellent cetane numbers – typically higher than diesel fuel. The viscosity of most biodiesel fuels is significantly higher than petroleum diesel. The colour of bio diesel ranges from golden and dark brown, depending on production method. It is miscible with water, has high boiling point and higher vapour pressure. The biodiesel does not contain any amount of sulphur and it is often used as an additive to low sulphur diesel fuel to aid with lubrication.

Literature survey:

Cashew nut shell liquid (CNSL) –Biodiesel: Sangeetha (2014), studied the performance, emissions and combustion characteristics of a singleCylinder constant speed direct injection diesel engine using cashew nut shell liquid diesel blends with different load conditions. The experiments were conducted CNSL diesel and diesel blends namely 20%, 40%, and 100 % (vol.basis) at different load condition and they were compared with diesel fuel. The showed that brake thermal efficiency (BTE) for CNSL was lower compare to diesel. The carbon monoxide (co), hydro carbon (HC), and nitrogen oxide (NO) were increased and smoke emission were decreased. We have studied about the performance and emission characteristics of a variable compression ratio engine with 20% and 25% cardanol diesel blends as a fuel. They reported that the addition of ethanol with bio fuel and diesel enhance the engine combustion process. The performance and emission are improved with 15% ethanol with bio fuel (BDEB15), CO, HC emission were decreased and NO emission is increased. Again we have studied experiment in diesel engine using cashew nut shell oil (CSNO), CSNO with 10% dimethyl carbonate (DMC) and CNSO with 0% diethyl ether (DEE) blends with different loading conditions. They reported that the brake thermal efficiency is increased for 10% DDE with CNSO compared to 10% DMC with CNSO and it is lower compared to diesel fuel operation. The smoke emission is decreased for 10% DDE with CNSO compared to 10%DMC with CNSO and it is higher than diesel fuel. The NO emission is lower for 10% DEE with CNSO compared with 10% DMC.

Properties of diesel and CNSL diesel blend:

Table.1.Properties of Diesel and CNSL

Properties	Diesel	CNSL
Density	840	932.6
Kinematic viscosity	4.59	19.2
Calorific value	42.5	41.5
Cetane number	45	54
Flash number	50	198
Fire point	60	206
Ash content	0.1	0.01

Palm Oil Biodiesel: Gnanamoorthi (2007), examined the plam oil bio diesel. In this biodiesel we have studied that, is biodiesel is prepared from palm oil by transesterification with methanol in the presence of 1.5%K loaded–calcined Mg-Al hydrotalcite. It contains of fatty acid methyl esters content of 96.9% and methyl ester yield of 86.6% were achieved using a 30:1 methanol to oil molar ratio at 1001C for 6h and 7wt% catalyst. The biodiesel was characterized and its impact on elastomer properties was evaluated. The compatibility of B10 diesel blend (10% biodiesel) with six types of elastomers commonly found in fuel systems (NBR, HNBR, NBR/ PVC, acrylic rubber, co-polymer FKM, and terpolymer FKM) were investigated. The physical properties of elastomers after immersion in tested fuels (for 22, 670, and 1008h at 1001C) were measured according to American Society of Testing and Materials (ASTM). These include swelling (mass change and volume change), hardness, tensile and elongation, as well as the dynamic mechanical property. The results showed that properties of NBR, NBR/PVC and acrylic rubber were affected more than other elastomers. This is due to the absorption and dissolving of biodiesel. It was tested as a 10% blend with a base fuel (B10) to find the performance of elastomers in fuel system component. This includes fuel system O-rings and hose materials. Elastomer compatibility testing include six types of elastomers (NBR, HNBR, NBR/PVC, acrylic rubber, co-polymer FKM, and terpolymer FKM). Tests were performed at 1001C for 23, 670, and 1008h followed by examination (% mass change, % volume change, % hardness change, tensile change, and elongation change).

We finally come to result for the transesterification of plam with methanol. The K-loaded calcined mg-Al hydrotalcite was found for the trans esterification of palm oil with methanol, the K-loaded calcined Mg-Al hydrotalcite was found to be an effective basic catalyst that gives methyl ester content of 96.9% and yield of 86.6%. This biodiesel was mixed with diesel to prepare B10 (10% blended with diesel). The important properties of biodiesel blend are quite close to that of diesel. The study of elastomer compatibility with B10 demonstrated little impact on the properties of elastomers. The results obtained from this work can assure consumer confidence in using B10

Properties of b100, b10, and bio-diesel:

Table.2. Properties of b100, b10, and bio-diesel

Property	Method	B100	B10	Diesel	Specification EN14214
Specific gravity	ASTM D4052	0.877	0.835	0.830	–
Methyl ester content	EN 14103	96.9	ND	–	496.5
Viscosity (mm^2/s) at 401C	ASTM D445	4.5	3.4	3.4	3.5–5.0
Cetane index	ASTM D976	50	57	59	–
Flash point (1C)	ASTM D93	142	65	63	4120
Cloud point (1C)	ASTM D1500	12.6	5	1	–

***Raphanus sativus* methyl ester in diesel engine:** Senthilkumar (2014), examined the combustion characteristics of Raphanus sativus methyl ester biodiesel. In which we have studied that the most attractive alternate energy source for fossil fuel is biodiesel.The potential use of Raphanus sativus oil for the production of biodiesel was investigated. Fatty acid profile of the Raphanus sativus oil was determined by using Gas chromatography (GC). Methyl ester production by transesterification of Raphanus sativus oil and the process parameter optimization was done to increases the yield percentage. The four important process parameters that influence the transesterification process are alcohol to oil molar ratio, catalyst concentration, temperature, reaction time. The yield percentage of Raphanus sativus methyl ester increases up to 94.5% at the optimized parameter values of alcohol to oil molar ratio, catalyst concentration, temperature, reaction time are 9:1, 1% wt, $50^{O}C$, 30 min respectively. Methyl ester blended with diesel at various proportions like B0, B20, B40, B60, B100 to analyse the performance of the diesel engine. The result shows that B20 blend gives the performance nearer to the diesel fuel. It was found that the emission level of carbon monoxide and hydrocarbon level were reduces with increase in the blend ratio.

Properties of *Raphanus sativus* Methyl Ester blends:

Table.3.Properties 0f Raphanus sativus Methyl Ester blends

Name of the properties	B0	B20	B40	B60	B100
viscosity at 40 ºC in CST	2.6	3.02	3.70	4.58	6.82
Gross calorific value in kJ/kg	45596	43876	42258	41723	41219
Flash Point in ºC	65	81	96	128	189
Fire Point in ºC	70	89	112	142	203
Cloud Point in ºC	-15	4	8	11	13
Specific gravity	0.82	0.8385	0.8408	0.8412	0.8428
Acidity	0.065	0.066	0.071	0.081	0.47

Residual oils recovered from spent bleaching earth: James chang (2010), analysed and compared the performance and emission characteristics of biodiesel and its blends. This work was to study technical and economic feasibilities of converting residual oils recovered from spent bleaching earth generated at soybean oil refineries into useable biodiesel. The fatty acids in the SBE residual oil were hexadecenoic acid (58.19%), stearic acid (21.49%) and oleic acid (20.32%), which were similar to those of vegetable oils. The methyl ester conversion via transesterification process gave a yield between 85 and 90%. The biodiesel qualities were in reasonable agreement with both EN 14214 and ASTM D6751 standards. A preliminary financial analysis showed that the production cost of biodiesel from SBE oils was significantly lower than the pre-tax price of fossil diesel or those made of vegetable oils or waste cooking oils. The effects of the crude oil price and the investment on the production cost and the investment return period were also conducted. The result showed that the investment would return faster at higher crude oil price.

Biodiesel properties in comparison with the standards:

Table.4.Biodiesel properties in comparison with the standards:

Property	ASTM D6751	EN 14214	Biodiesel This work	Testing methods
Specific gravity C (kg/m^3)	250.88	–	0.89	ASTM; D4052
Viscosity, 40 C (mm^2/s)	1.9–6.0	3.5–5.0	5.0	ASTM; D445
Water content (wt %)	0.05	–	0.05	ASTM; D2709
Sulfur content (wt %)	0.015 max	0.02	0.01 <	ASTM; D5453
Phosphorus (wt %)	0.001 max	0.001	0.001<	ASTM D4951
Methanol (wt %)	0.2 max	–	0.01	EN 14110
Ash content (wt %)	0.008		0.02 max.	
Flash point (C)	130 min	130 min	168	ASTM D93
Carbon residue (wt %)	0.05 max	0.02	0.05	ASTM D4530
Acid number (mg KOH/g)	0.5 max	0.8	0.5	ASTM D664
Iodine value (I_2/100 g)	–	120 max	27	ASTM D5768-2
Calorific value (kJ/kg	–	–	38,840	ASTM D240
Cetane number	47 min	47	61	ASTM D613

Biodiesel from Jatropha Oil as an Alternative Fuel for Diesel Engine: Kazi Mostafijur Rahman (2010), published a paper on emission and performance of diesel using Jatropha oil. It is also used as a biodiesel in different diesel engine. In this biodiesel we have studied about the different composition and different emission gas. The world is getting modernized and industrialized day by day. As a result vehicles and engines are increasing. But energy sources used in these engines are limited and decreasing gradually. This situation we need an alternative fuel for diesel engine. Biodiesel is an alternative fuel for diesel engine. The esters of vegetables oil animal fats are known as Biodiesel. This paper investigates the prospect of making of biodiesel from jatropha oil. Jatropha curcas is a renewable non-edible plant. Jatropha is a wildly growing hardy plant in arid and semi-arid regions of the country on degraded soils having low fertility and moisture. The seeds of Jatropha contain 50-60% oil. In this study the oil has been converted to biodiesel by the well-known transesterification process and used it to diesel engine for performance evaluation. It is clear that biodiesel from Jatropha oil is very necessary to us. It reduces greenhouse effect on our environment by reducing CO2 gas emission. It is very friendly with environment because it increases percentage of O2 in exhaust gas than the ordinary diesel. The economics of biodiesel fuels compared to traditional petroleum resources are marginal; public policy needs to be revised to encourage development. As Jatropha curcas is easy to cultivate so by planting of Jatropha, Bangladesh can save a huge amount of importing of petroleum products from foreign Biodiesel is a viable substitute for petroleum-based diesel fuel. Its advantages are improved lubricity, higher cetane number, cleaner emissions (except for NOx), reduced global warming, and enhanced rural development. Jatropha oil has potential as an alternative energy source

Engine Performance Using Diesel and Biodiesel:

Table.5. Engine Performance Using Diesel and Biodiesel

Performance	Diesel	Biodiesel	50% Biodiesel & 50% Diesel
Brake power, kw	0.466	0.895	0.339 Specific fuel
consumption, g/kwhr	784	629.74	741298
Mass of fuel, kg/hr	0.712	0.62	0.44
Brake thermal efficiency,%	11.76	24.09	10.8
Mass of air, kg/hr	7.945	5.52	8.49
Air fuel ratio	31.15	8.9	19.13

The Exhaust Gas Analysis:

Table.6.The Exhaust Gas Analysis

% of sample gas	Diesel	Biodiesel	50%Biodiesel & 50% Diesel
CO2	9	1.33	5
O2	5	17.67	8
CO	1	0	1

Pine oil –pongomia methyl ester blends in adiesel engine: Gnanamoorthi (2015), tasted the performance and emissions of a diesel engine by using pine oil. A double biofuel strategy to completely eliminate the use of diesel in a diesel engine without any engine modification. The conventional petroleum fuels for internal combustion engines will be available for few years only, due to tremendous increase in the vehicular population. Moreover, these fuels cause serious environmental problems by emitting harmful gases into the atmosphere at higher rates. Generally, pollutants released by engines are CO, Unburnt hydrocarbons, NOx, smoke and limited amount of particulate matter. Pine oil, synthesized from pine oleoresin, is recently being viewed as a potential renewable source of fuel for diesel engine application. Significantly, the estimated physical and thermal properties of pine oil are suited for its use in diesel engine, with the notable advantages of lower viscosity, boiling point and comparable calorific value with diesel. In this study, we decidedly conceived a strategy to blend it with a biodiesel, instead of diesel, so as to look out for double biofuel, a measure aimed at complete replacement of fossil fuels. As such, in the current investigation, POME (Pongamia methyl ester), a biodiesel derived from Pongamia oil, was blended with pine oil in various proportions such as B25P75, B50P50 and B75P25. Further, the major emissions such as HC (hydrocarbon), CO (carbon monoxide) and smoke forB50P50 were observed to be 8.1%, 18.9% and 12.5% lower than diesel at full load condition, while NOX (oxides of nitrogen) emission was in par with diesel. It can be used as blend fuels such as alcohol–diesel blendand alcohol–diesel emulsion in a diesel engine without any modifications, which is regarded as the simplest and attractive method, though complete replacement of diesel in any case is impossible. Research studies on the use of other less viscous fuel, in the likes of alcohols, such as eucalyptus oil and pine oil have also garnered much attention in the recent times.

The current work has attempted to use double biofuel, pine oil–POME blends, in a diesel engine and thereby, exclude the use of fossil diesel completely. From the experimental investigation, it was understood that BTE of the engine was increased by 8% for B25P75 than diesel at full load condition. Despite the lower HC, CO and smoke emission for B25P75 than diesel by 14.9%, 43.2% and 33.4%, respectively, it suffers the set back of higher NOX emission, owing to higher peak heat release rate. Moreover, at higher loads, the engine is prone to knocking and hence the adaptability of B50P50 for its operation in diesel engine is more amenable than B25P75. Not ably, the BSFC and BTE for B50P50 was observed to be in agreement with diesel, whereas the emissions such as smoke, HC and CO we refound to be 12.5%, 8.1% and 18.9% lower than diesel, with a comparable NOX emission with diesel. Thus, from the study, B50P50 could be regarded as an optimum blend among all the blends considereding respect of all factors such optimum properties attained, comparable performance with diesel and reduced engine emissions. Foreseeing the utilization of B50P50 for long term in a diesel engine, there might arise some durability issues like injector clogging or soot deposition due to the longer hydrocarbon chain length and molecular weight of biodiesel.

Table.7.Engine Specifications

Details	Specification
Make	Kirloskar-TV1
Type of engine	single cylinder, 4 stroke, Diesel engine (Computerized)
Compression ratio	17.5:1
Bore& stroke	87.5mm & 110mm
Method of loading	Eddy current dynamometer
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Method of cooling	Water
Type of ignition	Compression ignition
Injection timing	23 before TDC

Plastic Oil Biodiesel: Naima (2013), investigated experimentally the performance and exhaust emissions of a direct injection biodiesel using plastic oil biodiesel. The last 30 years have witnessed an explosive growth of the plastic industry. The production of synthetic polymers represented by polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyvinyl chloride (PVC) worldwide has increased more than 100 times in the last three decades. These plastics are widely used in many important day to day applications such as clothing, household appliances and in automotive products and aerospace. While we enjoy the conveniences that plastics can provide, the treatment of waste plastics becomes an unavoidable and imminent issue. In this regard, it can be safely stated that we are in urgent need and effective ways to recycle waste plastics. Recently new ways of environmentally-friendly waste plastic recycling have been of interest, and among them, the use of waste plastics as a supplemental fuel with coal in the steel making industry has attracted interest (Mitsuhara, 2001). Attention is also focused on using oil derived from waste plastics in diesel engines. Diesel engines are the most preferred power plants due to their excellent driveability and higher thermal efficiency (Williams and Williams, 1990). Plastics are non-biodegradable polymers mostly containing carbon, hydrogen and few other elements. Accordingto a nationwide survey conducted in India in the year 2000 approximately 6000 tonnes of plastic wastes were generated every day, and only 60% of it was recycled. In India alone, the demand for plastics is about 8 million tonnes per year. More than 10,000 metric tonnes/ day are produced in India and balance is imported from other countries. Most of the plastics are recycled and sometimes it is not done so due to lack of sufficient market value. Of the waste plastics not recycled about 43% is polyethylene and most of them is in the form of containers and packaging materials (Mani and Nagarajan, 2009). The extent of conversion of plastics or plastic derived waxes into light engine fuels can be increased by the application of stable hydro cracking catalysts however, very little work has been done to test their use in high-speed diesel engines.

From the test conducted with plastic oil and diesel on LHR engine, the following conclusion are arrived:-

- Engine was able to run with 100% waste plastic oil.
- Ignition delay was longer by about 2.5.
- CA in the case of waste plastic compare to diesel.
- NO_x is higher by about 25% for waste plastic oil operation then that of diesel operation.
- Co emission increased by 5%in waste plastic oil operation then that of diesel operation.
- Unburned hydrocarbon emission is higher by about 15%.
- Smoke reduced by 40% at rated power.
- Higher thermal efficiency up to 75% rated power

Comparison of fuel properties from waste plastic oil and diesel fuel

Table.8. Comparison of fuel properties from waste plastic oil and diesel fuel

Property	Waste plastic oil	Diesel
Density at 30°C in gm/cc	0.8355	0.840
Ash content, %	0.00023	0.045
Gross calorific value (kJ/jg)	44.340	46.500
Kinematic viscosity.	2.52	2.0
Cetane number	51	55
Flash point, °C	45	56
Carbone residus%	82.49	26
Sulphur content, %	0.030	0.045
Distillation temperature, °C at 58%	344	328
Distillation temperature, °C at 95%	362	340

2. CONCLUSION

Biodiesel is a valuable substitute for petroleum-based diesel fuel. Its advantages are improved lubricity, higher cetane number, cleaner emissions (except for NOx), reduced global warming, and enhanced rural development. In the cases of NOx emissions studies, a statistically significant increase in NOx emissions was found for B20 blends from the dynamometer data, while the on road studies resulted in a decrease that was not significant. In this research the optimum process parameters of Transesterification process were determine to get the maximum yield % of methyl ester. This showed that brake thermal efficiency (BTE) for biodiesel was lower compare to diesel. The carbon monoxide (co), hydro carbon (HC), and nitrogen oxide (NO) were increased and smoke emission were decreased. The performance and emission are improved with 15% ethanol with bio fuel (BDEB15), CO, HC emission were decreased and NO emission is increased. It reduces greenhouse effect on our environment by reducing CO2 gas emission. It is very friendly with environment because it increases percentage of O2 in exhaust gas than the ordinary diesel.

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