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A REVIEW ON THERMAL ANALYSIS ON FOUR STROKE C.I ENGINE USING BIODIESEL (COTTON SEED AND MAHUA)

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ABSTRACT :

Diesel engines are widely used in light, medium and heavy duty vehicles and power generation in heavy machinery, because of higher thermal efficiency and the ability for lean operation. Further, the lean burn capability helps to lower the carbon monoxide (CO) and Hydro carbon (HC) emissions compared to those of a spark ignition (SI) engine. However the emission of oxides of nitrogen (NO*x*) and particulate matter are higher in a diesel engine. Bio-fuels, due to their agricultural origin, are able to reduce net carbon dioxide (CO2) and CO emissions. Bio-fuels are having environmental benefits as they are made from renewable sources. Bio-diesel is biodegradable and it can be used in most diesel engines with minimum alterations in the engine manifold. In this paper Cotton seed and Mahua oil is used as raw material to produce a biodiesel. This paper reviews the Production of biodiesel from Cotton seed and Mahua oil, various properties, performance and emission of Cotton seed and Mahua biodiesel in compression ignition (CI) engine. Non edible and edible biodiesel blended with diesel were tested for their use as substitute fuels for diesel engines. This oil is blended in varying proportion like 10%, 20%, 30% etc. with diesel fuel and by varying the Compression ratio, Injection pressure, Speed, Load or by using Additives we can check the performance and emission characteristics of biodiesel-diesel blends and can find out the most preferable combination of the blend for CI engine. Based on various studies, this paper generally found that Cotton seed and Mahua biodiesel can be used in CI engines as alternative fuel.

1.INTRODUCTION

Biodiesel is one of the best available sources to fulfil the energy demand of the world. The petroleum fuels play a very important role in the development of industrial growth, transportation, agricultural sector and to meet many other basic human needs. However, these fuels are limited and depleting day by day as the consumption is increasing very rapidly. Moreover, their use is alarming the environmental problems to society. Hence, the scientists are looking for alternative fuels.India is importing more than 80% of its fuel demand and spending a huge amount of foreign currency on fuel. Biodiesel is gaining more and more importance as an attractive fuel due to the depleting nature of fossil fuel resources. The purpose of transesterification process is to lower the viscosity of the oil. The main drawback of vegetable oil is their high viscosity and low volatility, which causes poor combustion in diesel engines. The transesterification is the process of removing the glycerines and combining oil esters of vegetable oil with alcohol. This process reduces the viscosity to a value comparable to that of diesel and hence improves combustion. Biodiesel emits fewer pollutants over the whole range of air–fuel ratio when compared to diesel. Biodiesel can be produced by using different techniques such as ultrasonic cavitation, hydrodynamic cavitation, microwave irradiation, response surface technology, two-step reaction process etc. The researchers have tested a number of different raw and processed vegetable oils like rapeseed oil, sunflower oil, palm oil, soybean oil, Jatropha, PME, food grains, Karanja, Mahua, etc. In this paper, the results of some of the researchers have been compared and summarized.

2. 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.

3. MATERIALS AND METHODOLOGY

3.1. MATERIALS

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.,It is 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.

3.2. EXTRACTION OF COTTONSEEDS OIL

For extraction of cotton seed oil from cotton seed, two methods have been identified. They are the chemical extraction with n-hexane and mechanical extraction method in two stages using screw type of expellers. In the present study, the chemical extraction process gave the oil content about 23 to 33% from the cotton seed. In the two stages expellers the oil extracted were 30 to 38%.

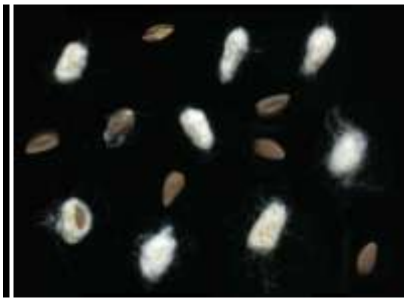

Fig. Cotton seeds

3.3. METHOD OF TRANSESTERIFICATION

The trans-esterification is two stage process i) Acid catalysed esterification and ii) Alkaline catalysed transesterification to convert esterifies oil in to methyl ester and glycerol. The esterifies oil (below 4% FFA) was taken for transesterification in the quantity of 1000 ml. 5 g of KOH was dissolved in to 250 ml of methanol and continuously stirred for 15 minute. After that this mixture was dissolved in to the 1000 ml of oil. This solution was then continuously heated and stirred at constant temperature of 55-60˚C for 2 hours. After the reaction is over, solution was allowed to settle down for 24 hours. Glycerine settles at the bottom and kusum methyl ester rises at the top. Methyl ester was then separated and purified with warm water. Transesterification.

Table 1

Raw oil and Blending Fuel Properties.

Fuel	Viscosity @ 40 °C (cSt)	Density@40 °C (Kg/m^3)	Flash point (°C)	Fire point (°C)	Calorific Values (Kj/Kg)
B100%	14.2	850	150	157	41,650
B80%	12.03	840	109	117	41,720
B60%	9.73	830	88	93	41,790
B40%	8.00	820	85	89	41,860
B20%	3.33	809	80	84	41,930
Raw oil	40.36	860	225	231	38,140

4. COMPARISION OF PROPERTIES OF DIESEL, VEGETABLE OILS AND BIODIESELS

Table 2

Thermodynamic properties of diesel and vegetable oil

Properties	Diesel	Karanja Oil	Mahua oil	Jatropha oil	Cotton seed oil	Linseed oil	Rapeseed oil	Kusum Oil
Cetane number	45	28.93	40	23	41.8	34.6	41.3	40
Viscosity@40 oC	3.05	35.98	39.45	35.98	33.5	27.2	37	40.36
Oil content wt%	-	25-50	35-50	20-60	17-25	35-45	25-35	25-36
Flash point oC	85	237	276	229	23	241	246	225
Pour point oC	-4	3	14	4	-4	-15	-31.7	--

Properties	JOME	KOME	M0ME	COME	LOME	ASTM	KME
Density (kg/m3)	862-886	865-898	828-865	872-885	874-920	870-900	850-830
Calorific value(MJ/kg)	37.2-43	36-42.1	36.8-43	40.1-40.8	37.5-42.2	-	35.0-41.65
Cetane number	43-59	36-61	47-51	45-60	48-59	47 min	42-48
Viscosity@ 40 °C	3-5.65	3.8-9.6	2.7-6.2	3.6-5.9	3.36-8.9	1.9-6	9-14.2
Flash point °C	180-280	110-187	5-208	70-200	161-181	>130	~150
Pour point °C	2-6	-6-10	1-6	-15-6	-18-14	-15 - 10	--

5. RESULT AND DISCUSSION :

5.1. BRAKE THERMAL EFFICIENCY

The brake thermal efficiency of CI engine is lower than that of the corresponding diesel fuel at all the engine speed.Thermal efficiency of preheated cotton oil was found slightly lower than diesel. The possible reason may be higherfuel viscosity. Higher fuel viscosity results in poor atomization and larger fuel droplets followed by inadequate mixing of vegetable oil droplets and heated air. However, thermal efficiency for preheated Jatropha oil was higher than unheated Jatropha oil. The reason for this behaviour may be improved fuel atomization because of reduced fuel viscosity (Agarwal D. and Agarwal A., 2007).

5.2. BRAKE SPECIFIC FUEL CONSUMPTION

Brake-specific fuel consumption is the ratio between mass fuel consumption and brake effective power, for a given fuel, it is inversely proportional to thermal efficiency. An experimental study on mahua oil methyl ester-diesel blends shows that the BSFC was found to increase with increasing proportion of biodiesel in the fuel blends with diesel, whereas it decreases sharply with increase in load for all fuels.

5.3 EXHAUST GAS TEMPERATURE

Experimental study of preheated cotton oil shows the variation of exhaust gas temperature for diesel and cotton oil(unheated and preheated). Result shows that the exhaust gas temperature increases with increase in brake power for each fuel. (Agarwal D. and Agarwal A., 2007).The variation of exhaust temperature with brake power for Diesel and other oils in the test engine. Exhaust temperature of Neem, Mahua and Castor are almost same as that of diesel in the mid range of load. This is an indication of lower exhaust loss and could be possible reason for higher performance.Exhaust temperature of Linseed is much higher than diesel (M.C.Navindgi et.al,2012).

5.4 SMOKE EMISSION

Smoke emission using Jatropha oil was greater than that of diesel. Heating the Jatropha oil result in lower smoke emission compared to unheated oil but it is still higher than diesel (Agarwal D. and Agarwal A., 2007).

For preheated RRO blends the smoke emissions decrease with the preheating. The most sufficient decreases were observed for rapeseed oil blends. The lowest smoke densities were obtained with preheated O50 and O20. Theaverage smoke densities were decreased by 9.4%, 20.1% and 26.3% for DF, O20 and O50, respectively. This may be due to the reduction in viscosity and subsequent improvement in spray (Hazar H. and Aydin H., 2010).

5.5 VISCOSITY

The viscosity of liquid (resistance offered by the inner layer of flow to the upper layer of liquid) fuel is an importantcharacteristic because it determines the flow through pipelines, injector nozzles and formation of fuel in cylinder. From the Table 1, it was observed that viscosity get regularly decreases as increasing proportion biodiesel-kerosene blend. Kerosene can be as diluents to reduce the viscosity.

5.6 SMOKE DENSITY

It is observed that smoke density for kusum oil blends is generally lower than that of diesel. However, at lower loads B100% kusum oil showed slightly higher smoke density than other blends but lower than diesel. At higher loads all the blends of kusum oil showed better emission performance than that of diesel. The possible reason for lower smoke density of kusum oil blends may be better combustion of fuel due to oxygen atom present in molecules of oil itself.

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 *f*orm 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.

- 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 viablediesel 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 NOx 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 NOx 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. 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 CO2 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 NOxemissions 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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