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OPTIMIZATION AND ENACTMENT INVESTIGATION OF TYRE PYROLYSIS OIL AND THEIR ASSORTMENTS IN COMPRESSION IGNITION ENGINE

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Abstract

Bio-diesel is one of the most promising alternatives for diesel needs. The present work has focused on the performance of tyre oil its blend with ethanol on a double cylinder, 4 stroke, naturally aspirated, direct injection, water cooled, and eddy current dynamometer kirloskar diesel engine at 1500 rpm for variable loads. Initially, tyre oil and their blends were chosen. The physical and chemical properties of tyre oil their blends were determined. In general, viscosity of neat tyre is high, which can be reduced through blending with ethanol and heating them. The performance and emission characteristics of engine are determined using tyre oil blend with ethanol. These results are compared to those of pure bio-diesel. By analyzing the graphs, it was observed that the performance characteristics are reduced and emission characteristics are increased at the rated load compared to those of bio-diesel. This is mainly due to lower calorific value, high viscosity and delayed combustion process. From the critical analysis of graphs, it can be observed that 20% of ethanol and with 80% of tyre oil is the best suited blend for diesel engine without any engine modifications. It is concluded that tyre oil can be used as an alternate to diesel.

Keywords: blend, volatility, Pyrolysis

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1. Introduction

In the current situation, the energy crisis due to fast depletion of fossil fuel is main problem. Increase in fuel price day by day, continuously growth of automobile industry, rapid growth in individual mobility and improved living standard, continuous accumulation of greenhouse gases are the main causes for development of alternative fuel and finding best alternative solution, which gives the best performance and fuel characteristics. Most of alternative fuels used today are biodiesel or bio ethanol which can be used in existing engines. The primary advantage of this kind of fuel is that they are renewable and eco-friendly and the research work is going on to increase maximum portion of alternate fuel in blend with diesel. With the use of alternate fuels, main issue is modification required in IC engines. The present civilization can't survive without motor cars and electricity. Fortunately, the last 25 years has seen growing awareness of some of these consequences. Since the dawn of oil age man has burnt about 800 million barrels of petroleum. About 71 barrels are burnt everyday throughout the

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world. And this consumption rate goes on increasing by 2% every year. The 2% doubles the quantity every 34 years. Somewhere between 1000 to 1600 billion barrels of fuel consumption are assumed to be in formation where economic recovery is possible. By 2010 the world would have consumed about one-half of the total amounts that is technically and economically feasible to extract. And at the current rate of consumption 1600 billion barrels would be depleted in 60 years. It's high time to think about the alternative fuels.

2. Tyre Oil

Majority of waste rubber products are generated from worn or damaged automotive tyres and industrial conveyor belts. In South Africa alone, over 200,000 tons of tyres were generated annually in 2010; about 11 million used tyres were disposed illegally or burnt to retrieve the steel wire, with this figure estimated to increase by around 9.5 % annually. Tyres consists of complex mixtures of very different materials which include several rubbers, carbon black, steel cord and other organic and inorganic minor components. Tyre oil is better fuel for his engine. With the advent of cheap petroleum, appropriate crude oil fractions were refined to serve as fuel and diesel fuels and diesel engines started evolving together. Later in the 1940's, tyre were used again as fuel in emergency situations, during the period of World War II. Because of the increase in crude oil prices, limited resources of fossil fuels and the environmental concern, there has been tyre oil production of bio-diesel fuel. Bio-diesel has the potential to reduce the level of pollution and the level of global warming and prevention of oxidation in storage, etc.

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3. Ethanol

It blends together with gasoline and diesel containing different amounts of water. The ethanol constitutes 5–10 percent of the overall fuel mass in the blend. There are two major reasons for using ethanol as an additive to gasoline, apart from any reduction in CO_2 emissions. First, adding ethanol to gasoline raises the octane number of the fuel blend, thus guarding against engine knock, which can damage the engine. Ethanol is thus able to replace more costly octane-boosting components such as alkylate. Second, because ethanol contains oxygen, ethanol containing gasoline burns more cleanly and reduces the amount of harmful emissions of carbon monoxide (CO), particulates and unburned gasoline components. Other oxygen-containing compounds can be added with the same effect. The ethanol used as an additive is normally anhydrous, in order to prevent phase separation (de-mixing) of the water and gasoline in the blend two other major types of ethanol blends, which are widely used in brazil, are gasohol, containing roughly 20 percent anhydrous ethanol in gasoline, and E100, hydrous ethanol without gasoline and with a water content of roughly 7 percent by volume. E100 has the advantage of a lower cost of production energy and consequently monetary cost compared to that for anhydrous ethanol, whereas gasohol has a better cold starting capability and much higher energy content per litter additionally.

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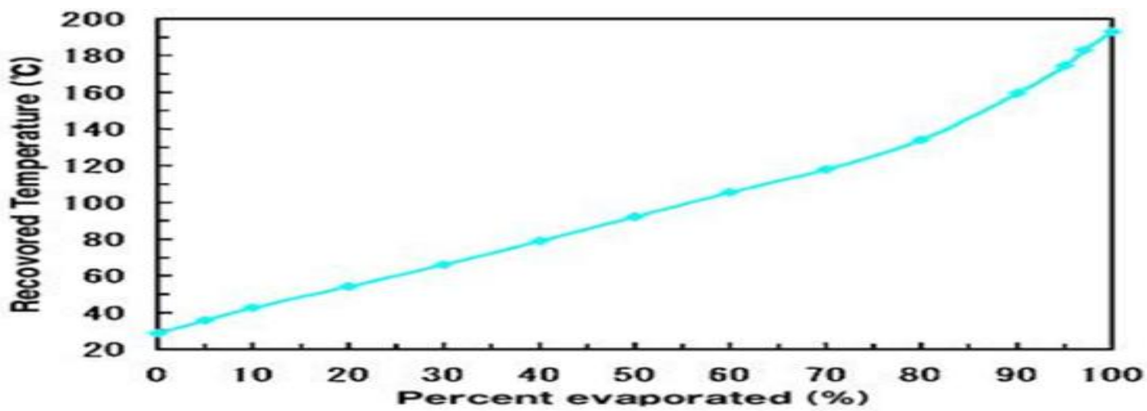
4. Volatility

Volatility is one of the main characteristic properties of gasoline which determines its suitability for use in a SI engine. Since gasoline is a mixture of different hydrocarbons, volatility depends on the fractional composition of the fuel. The usual practice of measuring the fuel volatility is the distillation of the fuel in a special device at atmospheric pressure & in the presence of its own vapour as shown in the figure 4.1. The fraction that boils off at a definite temperature is measured. The characteristic points are the temperatures at which 10, 40, 50 &



90% of the volume evaporates as well as the temperature at which boiling of the fuel terminates.

5. Starting and Warm Up

A certain part of the gasoline should vaporize at the room temperature for easy starting of the engine. Hence, the portion of the distillation curve between about 0 & 10 % boiled off have relatively low boiling temperatures. As the engine warms up, the temperature will gradually increase to the operating temperature. Low distillation temperatures are desirable throughout the range of the distillation curve for best warm-up.

6. Operating Range Performance

In order to obtain good vaporization of the gasoline, low distillation temperatures are preferable in the engine operating range. Better vaporization tends to produce both more uniform. Distribution of fuel to the cylinders as well as better acceleration characteristics by reducing the quantity of liquid droplets in the intake manifold.

7. Gum Deposits

Reactive hydrocarbons & impurities in the fuel have a tendency to oxidize upon storage form liquid & solid gummy substances. The gasoline containing hydrocarbons of the paraffin, naphthalene & aromatic families forms little gum while cracked gasoline containing unsaturated hydrocarbons is the worst offender. A gasoline with high gum content will cause operating difficulties such as sticking valves & piston rings carbon deposits in the engine, gum deposits in the manifold, clogging of carburetor jets & enlarging of the valve stems, cylinders & pistons. The amount of gum increases with increased concentrations of oxygen, with rise in temperature, with exposure to sunlight & also on contact with metals. Gasoline specifications therefore limit both the gum content of the fuel & its tendency to form gum during storage

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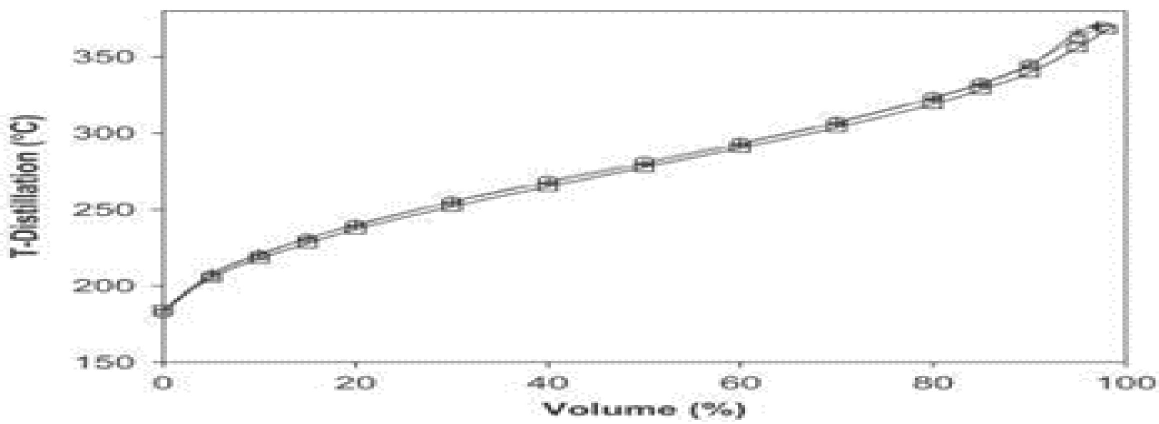
8. Volatility

.The fuel should be sufficiently volatile in the operating range of temperature to produce good mixing & combustionFigure above is a representative distillation curve of a typical diesel Fuel.



9. Tyre Pyrolysis Oil

The degradation of the rubber, using heat, in the absence of oxygen. The process is usually conducted under oxygen insufficiency or in an inert gas at either atmospheric or reduced pressures and in temperatures ranging from 300°-1000°C.Thick rubber at the periphery of the tyre was alone made into small chips. The tyre chips were washed dried and fed in to a mild steel pyrolysis reactor unit. The pyrolysis reactor used was a full insulated cylindrical chamber of inner diameter 110 mm and outer diameter 115 mm and height 300 mm. Vacuum was created in the pyrolysis reactor and then externally heated by means of 1.5 kW heaters. The process was carried out between 4500ºC and 650ºC in the reactor for 2 hours and 30 minutes [9.1]. The

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products of pyrolysis in the form of vapor were sent to a water cooled condenser and the condensed liquid was collected as a fuel. The non-condensable gases were let out to atmosphere. The TPO collected was crude in nature. For an output of 1 kg of TPO about 2.09 kg of waste tires feedstock was required. The product yields from the process are: tyre pyrolysis oil (50 %), pyro gas (40 %) and char (10 %). The heat energy required to convert the waste tyres into the products was around7.8 mJ/kg. The residence time of the pyrolysis process was 90 minutes TPO was filtered by fabric filter and again filtered by micron filter to remove impurities, dust, low and high volatilefractionsofhydrocarbons.1. Furnace 2.Reactor 3. Feed material 4. Temperature controller 5. Condenser 6. Water inlet 7. Water outlet 8. Pyrolysis oil collector

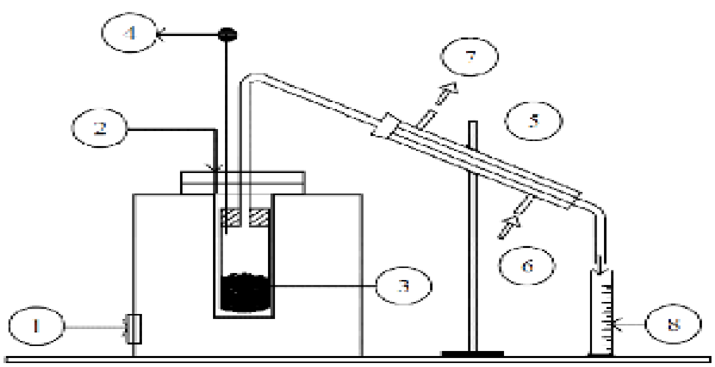

Figure: Pyrolysis setup

VARIOUS STEPS OF TPO

The modification of the crude TPO involves three stages,

(i) Removal of moisture content

(ii) Desulphurization process

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(iii) Vacuum distillation method.

VACUUM DISTILLATION METHOD

REMOVAL OF MOISTURE

Initially crude TPO was heated up to 100 °C, in a cylindrical vessel for a particular period to remove the moisture, before subjecting it to any further chemical treatment.

REMOVAL OF MOISTURE

Initially crude TPO was heated up to 100 °C, in a cylindrical vessel for a particular period to remove the moisture, before subjecting it to any further chemical treatment.

The sample was externally heated in a closed chamber. The vapors leaving the chamber was condensed in a water cooled condenser and the DTPO was collected separately.Non condensable volatile vapors were left to the atmosphere. The distillation was carried out between 180°C and 240°C. 75% of TPO was distilled in the distillation whereas 10% of TPO was left out as pyro gas and 15% was found as sludge. The time taken for obtaining 250 ml DTPO and 800 ml DTPO were 25 min and 60 min respectively. The DTPO has irritating odour like acid smell. The odour can be reduced with the help of adding some masking agents or odour removal agents. DTPO has about 7% higher heating value than crude TPO.

Three test fuels have been taken for the experimental work. The first one is standard diesel fuel (DIESEL) and other two are DTPO75 and DTPO85. DTPO75 is 75% DTPO blended with 25% DIESEL on volume basis. DTPO85 is 85% DTPO blended with 15% DIESEL on volume basis.

Property	Diesel	Tyre Pyrolysis oil
Heating value (k.T/kg)	42500	42580
Sulphur	1.2%	0.06%
Carbon residue (% by weight)	<0.38	0.11
Density (g/cc)	0.840	0.843
Kinematic Viscosity(cSt) at 40^{u}C	3.5	3.2

MOLECULAR FILTRATION

The distillates obtained at 250oc being the fractions that resemble diesel fuel underwent further treatment to reduce the residual sulphur compounds. Since a fraction of mercaptans were removed from the oil, the free sulphur remaining in the oil was reduced through adsorption using 13x molecular sieves. Zeolite molecular sieves are crystalline, highly porous materials, which belong to the class of alumina silicates.

The pore opening of the sodium form of zeolite x (13x) is approximately 8 angstrom. The ability to adjust the pores to precisely determined uniform openings allows for molecules smaller than its pore diameter to be adsorbed whilst excluding larger molecules, hence the name molecular sieve. The different pore sizes of synthetic zeolites open up a wide range of possibilities in terms of sieving molecules of different size or shape from gases and liquid.

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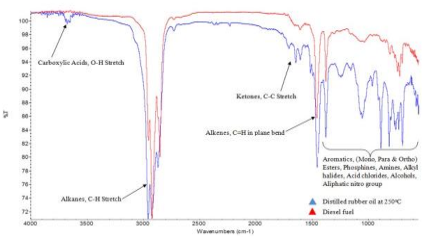
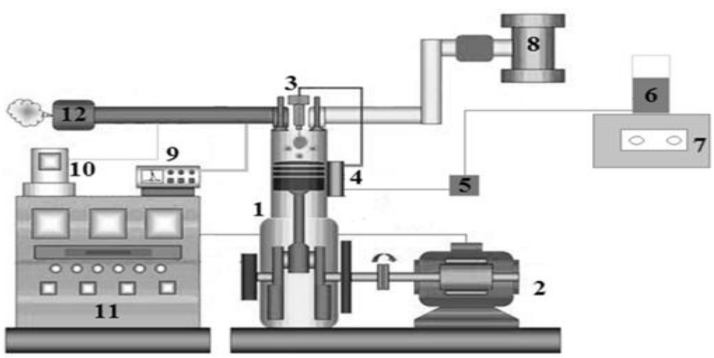


EMISSIONS

In the end use of ethanol fuels, there are two main concerns regarding fuel-related emissions; tailpipe emissions and evaporative emissions. Tailpipe emissions have been reduced over the years by increasingly strict regulations, while evaporative emissions have not had the same degree of focus. With the introduction of ethanol, evaporative emissions are in some cases at a level comparable to tailpipe emissions and must therefore be addressed.



Experimental Setup (Kirloskar Av-1 Engine)

PROCEDURE

 At first 100% diesel is taken for test.

 Then 100% tyre oil is taken for test without any blending.

The tyre oil and ethanol oil are mixed together to prepare a mixture. The proportion of mixing the two oils are 90%and 10%of the mixture is taken to prepare the blend. This is the second fuel to be tested.

 Then 80% of the mixture is taken and 20% is mixed to prepare the third blending. Likewise 30% blend is taken and tested.

The blend oil is put in the fuel tank, the engine is started first we have to take the reading

OBSERVATION TABLE.

ENGINE SPEED IN RPM	B.P IN KW	100%LOAD RE=VALM.NM	DYNO CONST	FR.POWER R IN KW
1500	3.7	114.7	9549.305	1.4

CONSTANCE VALUE FOR ENGINE:

Constance Value for Enginefor 0 load and time taken to consume 20ml of oil is noted down. Afterwards load is increased gradually as 20%, 40%, 60%, 80%, and 100%.

% OF LOAD	FUEL CONSUMPTION	FUEL POWER	BRAKE.SP.FUEL CONSUMPTION
%	Kg/hr	Kw	Kg/Kw.hr
20	0.521739	6.655507	0.724638
40	0.586957	7.487446	0.404798
60	0.705882	9.004510	0.320856
80	0.874494	11.15538	0.288612
100	1.018868	12.99708	0.276116

100% DIESEL FUEL READING:

Load Test on Kirloskar Av-I Engine (E swing Field Dynamometer)

LOAD	CAL LOAD	ENGINE SPEED	TIME TAKEN FOR 10CC			EGT	BRAKE POWER	THERMAL EFFICNCY
%		RPM	T1	T2	T AVG	DEG C	Kw	%
20	2	1500	210	220	215	89	0.72	12
40	4.6	1500	174	180	177	133	1.45	20

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60	7.2	1500	132	136	134	161	2.2	25
80	9.8	1500	117	118	117.5	196	3.03	28
100	11	1500	108	110	109	211	3.69	31

TYER OIL 100%

% OF LOAD	FUEL CONSUMPTION	FUEL POWER	BRAKE.SP.FUEL CONSUMPTION
%	Kg/hr.	Kw	Kg/Kw.hr
20	0.493151	6.177808	11.65462
40	0.591781	7.41337	19.55926
60	0.797048	9.984797	29
80	0.943231	11.81607	33
100	1.15508	14.46995	37

Load Test on Kirloskar Av-I Engine

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90% TYRE OIL + 10% ETHANOL:

LOAD	CO	HC	CO2	O2	NO
(Kg)	Ppm	% by vol	% by vol	% by vol	ppm
20	0.04	35	2.94	10.95	183
40	0.03	41	4.02	10.74	372
60	0.02	47	5.24	10.21	705
80	0.02	52	6.64	9.57	990
100	0.02	55	7	9.37	1117

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LOAD	CAL LOAD	ENGINE SPEED	TIME TAKEN FOR 10CC			EGT	BRAKE POWER	THERMAL EFFICNCY
%		RPM	T1	T2	T AVG	DEG C	kw	%
20	2	1500	219	220	219.5	148	0.72	14
40	4.6	1500	176	180	178	154	1.45	21
60	7.2	1500	134	136	135	175	2.2	26
80	9.8	1500	114	118	116	190	3.03	29
100	11	1500	105	117	107.5	203	3.69	33

80% TYRE OIL + 20% ETHANOL

Load Test on Kirloskar Av-I Engine (E Swing Field Dynamometer)

LOAD	CAL LOA D	ENGINE SPEED	TIME TAKEN FOR 10CC			EGT	BRAKE POWE R	THERMAL EFFICNCY
%		RPM	T1	T2	T AVG	DEG C	Kw	%
20	2	1500	213	225	219	135	0.72	11.65462
40	4.6	1500	185	180	182.5	143	1.45	19.55926
60	7.2	1500	135	136	135.5	162	2.2	29
80	9.8	1500	111	118	114.5	192	3.03	33
100	11	1500	90	97	93.5	213	3.69	37

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LOAD	**CO**	**HC**	**CO2**	**O2**	**NO**
% by vol	Ppm	% by vol	% by vol	% by vol	ppm
20	0.04	32	2.78	10.61	170
40	0.03	42	3.98	10.29	367
60	0.02	44	4.5	10.36	545
80	0.02	49	5.8	10.04	866
100	0.02	60	7.62	9.94	1056

Fig Table: 7.6(a)

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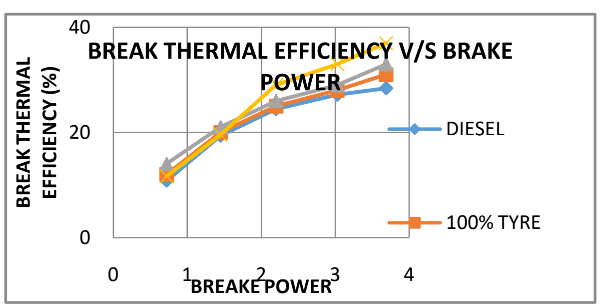
% OF LOAD	FUEL CONSUMPTION	FUEL POWER	BRAKE.SP.FUEL CONSUMPTION
%	Kg/hr.	Kw	Kg/Kw.hr
20	0.493151	6.177808	11.65462
40	0.591781	7.41337	19.55926
60	0.797048	9.984797	29
80	0.943231	11.81607	33
100	1.15508	14.46995	37

Fig Table: 7.6(b)

PERFORMANCE CHARACTERISTICS

BREAK THERMAL EFFICIENCY V/S BRAKE POWER



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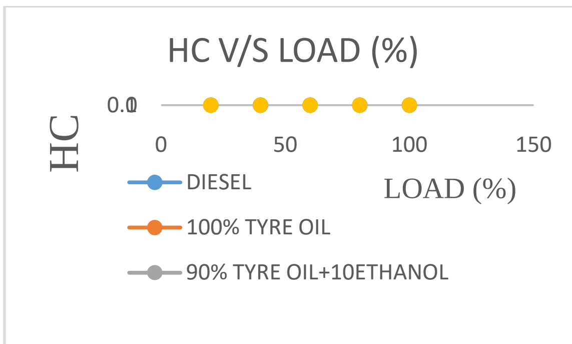
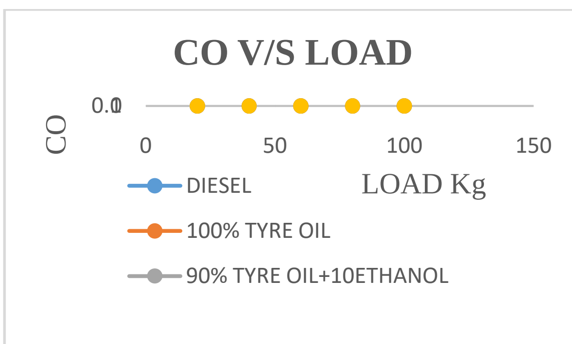
BRAKE SPECIFICI FUEL CONSUMPTION V/S BRAKE POWER

HC V/S LOAD(%)



CO V/S LOAD(%)



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LOAD	CO	HC	CO2	O2	NO
% by vol	ppm	% by vol	% by vol	% by vol	ppm
20	0.06	27	3.08	8.77	188
40	0.05	28	4.4	8.4	390
60	0.03	26	5.8	7.98	694
80	0.03	26	7.1	7.75	1029
100	0.04	27	8.42	7.03	1279

CONCLUSION

The findings of this study revealed that the fuel properties of distilled oil obtained at 250^{o}C are nearly comparable to commercial diesel with high heating value as well as low water content and total contamination. It was also discovered that the oil cannot be used directly into compression ignition engines in its pure form due to its higher sulphur content, low viscosity and low flash point. A blend of this oil with diesel fuel may be considered to an extent whereby the overall viscosity and flash point of the blend fuel is at least 2.2cst and 55oc respectively. The sulphur content in the oil was reduced by 22.5% via distillation process and further 44.4% by molecular filtration using 13x molecular sieves.

As the above graphs shows that 10% blending gives us optimum values of performance and emission characteristics blends have lower value of co, unburnt hydrocarbon than diesel.

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This is due to better combustion of fuel inside the cylinder than diesel. The brake thermal efficiency, brake specific fuel consumption of blends is lower and higher (except 10% blending) respectively than diesel, this is due to higher viscosity and lower calorific value of the fuel. The properties like density, viscosity, and flash point of blends is higher and calorific value is almost 0.8 to 0.9 times that of bio diesel.

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