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Study and Analysis on Bio-Fuels

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ABSTRACT:

Fuels derived from biomass are mostly preferred as alternative fuels for IC engines as it is abundantly available and is renewable in nature. As most of vegetable oils are edible, growing concern for trying non-edible and waste fats for alternative to petro diesel has emerged. In present study diesel fuel is completely replaced by bio-fuels namely methyl ester of palm kernel oil and eucalyptus oil in various blends. Different blends of palm kernel oil and eucalyptus oil are prepared on volume basis and used as operating fuel in single cylinder diesel engine over a variable compression ratio engine by varying the compression ratios. Performance and emission characteristics of these blends are studied by varying the compression ratio. In the present experiment methyl ester extracted from palm kernel oil is considered as ignition improver and eucalyptus oil is considered as the fuel. The blends taken are PKE 10(palm kernel oil 90+eucalyptus 10) PKE30 (palm kernel oil 70+eucalyptus 30) and PKE50 (palm kernel 50+ eucalyptus 50). The results obtained by operating with these fuels are compared with results of pure diesel; finally the most preferable combination and the preferred compression ratio are identified.

1.INTRODUCTION:

Continuous raise in fuel price, increase in number of road vehicles, depletion of petroleum resources and increase in green house gases are the main reasons for the search of alternative fuels. Up to now many alternative fuels are identified from different resources like waste vegetables, plants, animal fat etc., these are successfully tested over engine with slight modifications in engine or without any modifications. But unfortunately every fuel is experiencing some sort of problem so that these cannot be replaced the existing fuel. Bio fuels can be renewed. These are eco-friendly since these are extracted from plants, animals.

In general oils extracted from plants are classified into two categories. They are triglyceride oils (TG oils) and turpene oils (light oils). In present study triglyceride oils are used. Triglyceride oils are extracted from plant seeds but eucalyptus oil is taken from the leaves and young twigs of plant.Present study involves two triglyceride oils namely eucalyptus oil and methyl ester of palm kernel oil. Eucalyptus oil is prepared from leaves and young twigs of plant whereas palm kernel oil is prepared from palm seed. Eucalyptus oil alone cannot replace diesel in diesel engine since the Cetane number of eucalyptus oil is insufficient. But the blended form of eucalyptus and methyl ester of palm kernel can replace diesel to a maximum extent since the properties of blends are nearer to the properties of diesel fuel. These blends can be used over diesel engine without any further modifications.In the present work performance, emission and combustion characteristics of these bio fuel blends are examined over a 4 stroke direct injection diesel engine by varying the compression ratio.

2.BIO- FUELS:

Demand for bio-fuels can increase the real commodity prices that has made down agricultural growth in developing world over recent years. Use of bio-fuels may offer an opportunity for developing countries. In recent years liquid bio-fuels have grown rapidly in terms of volume and to share of global demand for transport energy. The growth is projected to continue which shows historical trends as well as projections to 2015 and 2030, as reported in the world energy outlook 2012 (IEA,2012). Biomass and waste products currently cover 10percent of global primary energy demand.

» Compressed Natural Gas (CNG):

Natural gas is the combination of hydrocarbons. It is mainly composed of methane. As it contains lower energy density it is compressed to pressure of 20-25 Mpa for easy storage in cylinders located in vehicles.

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» Liquefied Petroleum Gas (LPG):

LPG is composed of propane and butane with minute percentages of propylene and butylenes. High octane number, lesser emissions, less carbon content is the advantages of LPG.

SELECTION OF BIO FUEL:

Some of requirements must be satisfied while selecting a bio fuel.

» Production of bio fuel should be in local so that transportation charges can be reduced.

» Production plant required for this fuel production should be at minimum possible cost but should give high quality.

» Emissions should be low when used and even during the production.

BIO-FUEL:

Bio fuel is the best alternative for diesel engine. Bio fuel is produced from the combination of vegetable oil or animal fat with alcohol in the presence of catalyst by a process known as esterification and transesterification. Bio fuel can be produced from palm, coconut, jatropha, pungamia, neem, cotton seed etc., and higher oxygen content of biofuel aids in the completion of fuel combustion, reducing emissions of particulate air pollutants, carbon monoxide and hydro carbons.

Advantages of bio-fuel:

» Eco friendly
» Fuel is renewable
» No need of modifications in engine
» Engine life increases
» Non toxic
» Pollutant free
» Bio degradable
» Cheaper than diesel
» Safe fuel
» Cetane number is higher than diesel
» Higher oxygen content
» Higher flash point than diesel
» Carbon content is less
» Oil is safe, toxic
» No need of change in refueling infrastructures and spare part inventories.
» Reduction of green house gases.
» Social structure and agriculture
» Oil contains 11% oxygen, so that it burn totally whereas in diesel oxygen is null.
» Security of supply.

Disadvantages of bio-fuel:

»
» Slight increase in NOxemissions. But these can be eliminated by usage of catalytic converter.
» Bio fuels cannot be stored for large period of time.
» 100% biodiesel usage leads to a variety of engine problems. Like injection choking, piston ring sticking and breaking.
» At low temperatures biodiesel is thicker than normal diesel... this can be solved through winterizing agents.
» Biofuel must be free of impurities.
» Biofuel is corrosive and a good solvent.
» Bio fuel removes paint, melts rubber and plastic components.
» Because Biofuel varies based on manufacturing process and the source materials used, elastomeric compatibility with Biofuelremains unclear; therefore when Biofuel are used the condition of seals, hoses, gaskets and wire coatings should be checked out regularly.
» At low temperatures Biofuel is thicker than conventional diesel fuel, which limits its use in certain geographic areas. This can be solved through the use of winterizing agents also used in petroleum based diesel fuel or you can store the Biofuel in a warm location or heat the fuel tank.

USES OF BIO FUEL:

» Biofuel has high Cetane number. This helps in easy cold starting and low idle noise.
» Biofuel is non toxic, bio degradable. Emissions can be reduced.
» Use of bio fuel can increase the engine life period.

Benefits in national interest:

» Energy independent
» Environmental safety
» Self dependent villages, transportation
» Barren land will be under cultivation.

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» Generating power to meet their basic needs.
» Increasing local employment during dry season.
» By generating extra income from irrigated lands during off seasons.
» Rural development
» Reducing the use of fossil fuel.

PROPERTIES OF BIO FUELS:

Fuels:

fuels are substances which combine with air will yield heat. The chemical combination of fuel and oxygen in air produces products of combustion containing CO, CO_2, H_2O, SO_2 and N_2. Fuels exist in any of the three stages such as gaseous fuels, solid fuels and liquid fuels. Gaseous fuels: It can mix with and distribute homogeneously to various cylinders in a multi cylinder engine. They are mostly used as natural gas, coke, oven gas, blast furnace gas, producer gas and liquefied petroleum gas.

Solid fuels:

They are coal. The main obstacle is the excessive wear of the cylinder liners and piston rings. The sulphur content is greater in coal. This causes corrosive wear. Ash formation is another problem.

Liquid fuels:

Most liquid fuels are derived from crude oil or petroleum which is exiting at different parts of the world. The liquid fuels can be put into two main groups, liquid fuels which can be handled like gases and liquids which have to be injected into the combustion chamber in the form of spray. Former group is used in SI engines while the latter group is used in CI engine. The most important liquid fuels used in engines are gasoline (petrol), fuel oil (diesel), gas oil and kerosene and alcohols.

General properties of fuel:

The fuel characteristics include the physical and chemical properties of the fuel such as viscosity of fuel, pour and fire point of fuel, calorific value of fuel and ignition quality (Cetane number).A general understanding of the various properties of bio diesel is essential to study their implications in engine use, storage, handling and safety.

Density/Specific gravity:

Biodiesel is slightly heavier than the mineral diesel fuel(specific gravity 0.859 compared to 0.850 for biodiesel.) This allows use of splash blending by adding bio-diesel on top of diesel fuel for making bio-diesel blends. Bio diesel should always be blended at top of diesel fuel.

Kinematic viscosity:

Viscosity is an important physical property of a biodiesel fuel. Improper viscosity leads to poor combustion, which results in loss of power and excessive exhaust smoke. Diesel fuels with extremely low viscosities may not provide sufficient lubrication for the closely fit pumps and injector plungers. They can promote abnormal wear and cause injector and injector pump leakage and dribbling leading to loss of power as fuel delivered by injector is reduced. Diesel fuel with higher viscosity is also not desirable as too viscous fuel increase pumping losses in injector pump and injectors, which reduces injection pressure resulting in poor atomization and inefficient mixing with air ultimately affecting the combustion process.

Flash and fire point:

Flash point of a fuel is defined as the temperature at which the oil will ignite when exposed to a flame or spark. The flashpoint of bio diesel is higher than the petroleum based diesel fuel. Flash point of biodiesel is dependent of the base diesel fuel used and increase with the increase in percentage of bio diesel in the blend. Residual alcohol in the biodiesel reduces its flash point drastically and is harmful to fuel pump, seals etc., It reduces the combustion quality.

Cloud point:

Cloud point is the temperature at which a cloud or haze of crystal appear in the fuel under test conditions and thus becomes important for low temperature operations. Bio diesel generally has higher cloud point than biodiesel and petro diesel is almost comparative.

POUR POINT:

Pour point is the lowest temperature at which petroleum product will begin to flow

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Normally pour point or cold filter plugging point (CFPP) is specified. Pour point depressants generally used for diesel fuel do not work for biodiesel.

Cetane number:

Cetane number of a fuel is the indicative of its ignition characteristics. Higher the Cetane number better it is in its ignition properties. Cetane number affects a number of engine performance parameters like combustion, stability, drive ability, white smoke, noise and emissions of CO and HC. Bio diesel has higher Cetane number than conventional diesel fuel. This results in higher combustion efficiency and smoother combustion.

FFA Content:

If the oil has a high water or free fatty acid (FFA) content the reaction will be unsuccessful due to saponification. Saponification is termed as reaction of an ester with a metallic base and water. Commonly known as making soap, and make separation of glycerol difficult at the end of the reaction. The FFA content of the raw oil will determine the quantity of the biodiesel as a final product. Low content of FFA i.e., less than 0.2 can give a full yield. But unfortunately the FFA content of Jatropha oil is 10. Therefore the seeds should be stored at a temperature below 40C and these should be collected on a sunny day. FFA content varies with seed quality, transport and storage.

Calorific value:

The total quantity of heat liberated by complete combustion of one unit mass of fuel is termed as calorific value.

Ash content:

The amount of inorganic contaminants such as abrasive solids and catalyst residues and the concentration of soluble metal soaps contained in a fuel sample are termed as ash content. These compounds are oxidized during the combustion process to form ash which is connected with engine deposits.

Carbon residue content:

It gives the relation in the amounts of glycosides, free fatty acids, soaps and catalyst residue.

The parameter serves as a measure of the tendency of a fuel sample to produce deposits on injector tips and inside the combustion chamber. It is also influenced by high concentration of polyunsaturated fatty acid methyl esters and polymers.

Specification for biofuel:

Specifications and standards are of major important parameters for any biodiesel product producers, suppliers and users of bio diesel. Standards are required for the evaluation of safety, risks, environmental problems approval and warrantee of vehicles. Creation of standards shall help to expand the market for renewable sources of energy in India as well as world. Generally standards and codes are developed by examining the existing standards and codes in different countries and then writing standards for the own country. In December 2001, American society of testing and materials (ASTM)issued a specification (D6751) for biodiesel (B100) which is presented below:

Property	ASTM method	Limits	Units
Flash point	D93	130 min	Degree C
Water& sediment	D2709	0.050 max	%volume
Kinematic viscosity	D445	1.9-6.0	Mm^2/sec
Copper strip corrosion	D130	No.3 max	----
Cetane	D613	47min	----
Cloud point	D2500	Report	Degrees C
Carbon residue(100 % sample)	D4530	0.050 max	%mass
Acid number	D664	0.80max	Mg KOH/gm
Free glycerin	D6584	0.020 max	%mass
Total glycerin	D6584	0.240max	%mass

TABLE1: ASTM specification (D6751) for biodiesel (B100) (17):

POTENTIAL CHARACTERIZATION OF PALM KERNEL OIL:

The oil palm Elaeisguineensis (guineensis referring to its country of origin) is native to West Africa. Mature trees are single-stemmed, and grow to 20m tall.

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The palm fruit takes five to six months to mature. Each fruit which is reddish and made up of an oily, fleshy outer layer (the pericarp), with a single seed (the palm kernel), also rich in oil. Oil is extracted from both the pulp of the fruit and the kernel. For every 100 kilograms of fruit bunches, typically 22 kilograms of palm oil and 1.6 kilograms of palm kernel oil can be extracted.

FIG1: PALM KERNEL SEEDS

POTENTIAL CHARACTERIZATION OF EUCALYPTUS OIL:

A few eucalyptus species mainly melees produce leaf oil. The botanical name is eucalyptus globules. These oils are composed of mixture of volatile organic compounds including hydrocarbons, alcohols, aldehydes, keytones, acids, ethers and esters. 1-8 cimneole or simply cineole is active component of eucalyptus oil.

Cineole is as cyclic ether with empirical formula C10H18O and systematic name 1, 3, 3- trimethy, 1-2-oxabicyclo octane (Ramesh B et al (1994)). It is sometimes traded commercially as eucalyptol. It is a colorless liquid over the temperature range 0c to 177c with a vapor pressure of 69 mm of Hg at 20c and a strong characteristics odour.

FIG2: EUCALYPTUS TREE

PRODUCTION OF BIOFUEL:

Step 1: Collection of palm kernel seeds, eucalyptus seeds and extraction of oil:

Palm kernel seeds and eucalyptus seeds are taken to vessels and boiled with water at a temperature of 1000 C for a time period of 120 minutes. After that the water is evaporated and the stock is squeezed to extract the oil.

Step 2: Purification of oil:

The palm kernel oil and eucalyptus oil are separately filtered to remove dirt, non-oil material often found in oil. Water is removed because its presence causes the triglycerides to hydrolyze to give salts of the fatty acids instead of undergoing transesterification to give biodiesel. This is often accomplished by heating the filtered oil to approximately 1200 C. At this point, dissolved or suspended water will boil off. When water boils it bumps. To prevent injury this operation is done in a sufficiently large container which is closed.

Step3: Mixing of alcohol and catalyst to the raw oil:

The catalyst used is generally sodium hydroxide or calcium oxide. It is dissolved in methyl alcohol by using a stirrer.

Step 4: Esterification:

During esterification process(1) the triglyceride is reacted with alcohol in the presence of catalyst usually a strong alkali like sulphorus acid. The main reason for doing such titration to produce biodiesel is to find how much alkali is needed to neutralize free fatty acids.

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This completes the transesterification process. The alcohol reacts with fatty acids to form mono-alkyl ester and crude glycerol. The reaction between bio lipid and alcohol is a reversible reaction so alcohol must be added in excess to drive the reaction towards right and ensure complete conversion.

Step5: Transesterification(1):

The alcohol and catalyst mixture is then added to the oil. From here the procedure is completely done in a closed vessel. The mix is kept above the boiling point of alcohol to speed up the process. And the reaction takes place. The recommended time for reaction is 1 to 8 hours. Care must be taken to monitor the amount of water and free fatty acids in the oil. If the free fatty acid level or water level istoo high it may cause problems with soap formation and the separation of glycerin by product.

FIG3: TRANSESTRIFICATION

Step6: Separation of glycerol and biodiesel:

Once the reaction is completed two major products exits they are glycerin and biodiesel. Each product has a substantial amount of excess methanol that was used in reaction. The glycerin phase is denser than biodiesel phase and the two can be gravity separated with glycerin simply drawn off the bottom of the settling vessel.

In some cases centrifuge is used to separate both the products. Crude glycerol the heavier liquid will collect at bottom after several hours of settling. Phase separation can be observed within 10min and can be completed within 2 hours after stirring has stooped.

fig4: Seperation of glycerol and bio fuel

Step7: Alcohol removal:

Once glycerin is separated the excess alcohol in each phase is removed with a flash evaporation process or by distillation. In some systems alcohol is removed and the mixture is neutralized before the glycerin and esters have been separated. Care must be taken to ensure no water accumulates in the recovered alcohol stream.

Step 8: Final process:

After separation of glycerin the biodiesel is purified by washing gently with warm water to remove residual catalyst or soaps and sent to storage. But in some processes this step is unnecessary. In some process the bio diesel is distilled in an additional step to remove small amounts of color bodies to produce a colorless biodiesel.

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Oils/Blends	Viscosity (cst)	Calorific value(Kcal/Kg)	Density (kg/m^3)
Diesel	3.25	42,700	0.840
Palm kernel oil	4.839	37,250	0.883
Eucalyptus oil	2.024	43,270	0.991
Palmkernel90 +eucalyptus10	4.246	38,158	0.892
Palmkernel70 +eucalyptus30	3.986	40,350	0.889
Palmkernel50 +eucalyptus50	3.826	41,793	0.880

FIG 4: FINAL PRODUCT

Properties of blends required for the experiment:

Table2: (Data obtained from ITA labs, Chennai)

3.EXPERIMENTAL SETUP:

Equipment description:

A single cylinder, four stroke, constant speed, air cooled, direct injection diesel engine is used for the present study.

» The experimental setup consists of variable compression ratio ignition engine.
» The loading is by means of electrical dynamometer.
» Water cooling system, various sensors and instruments integrated with computer data acquisition.
» A five gas analyzer is used to obtain the exhaust gas consumption.
» Set up enables the evaluation of thermal performance emissions constituents.
» Thermal performance includes brake thermal efficiency, indicated thermal efficiency, mechanical efficiency, brake specific fuel consumption, exhaust gas temperature.
» Technical specifications are as below:

Engine	4 stroke 1 cylinder
Lubrication	Water cooled engine
Rated Power	3.7 Kw
Compression Ratio	12:1 to 20:1
Rated speed	1500 rpm
Dynamometer	Eddy current dynamometer
Stroke length	110mm
Bore Dia	80 mm
Make	kirloskar

Table3 : Engine specifications
Engine picture:

FIG 5: ENGINE SETUP

Instrumentation:

Load measurement: Electrical dynamometer is used for load measurement.

Engine speed measurement: Engine speed was at rated speed 1500 r.p.m throughout the experiment.

Measurement of exhaust emissions:

The constituents of exhaust emissions measured are Co2 , HC, O2 , NOx ,SOx.

NECCESITY OF VARIABLE COMPRESSION RATIO:

The present challenge in automotive engine technology is the improvement of efficiency and hence the fuel economy and lower emission levels.

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Compression ratio is the key feature which affects the efficiency of the engine.

COMPRESSION RATIO SETTING:

The engine with fixed compression ratio can be modified by providing additional variable combustion space. This can be achieved by different achievements. Tilting cylinder block method is one of the arrangement which can be used to vary the combustion space.

EXPERIMENTAL PROCEDURE:

» Make all the electric supply switches ON and check water supply connections to engine and dynamometer through rotameter.
» Make fuel supply ON if separate arrangement is done for storage and supply of biodiesel.
» After conditioning the equipment the engine is started and warm up for 10 minutes.
» Load the engine gradually using knob in control panel.
» Note down the readings like fuel consumed, load applied, speed
» Calculate torque and B.P using formulae.
» Repeat the above procedure for all the blends at different compression ratios.
» Each test is conducted and data is stored at five different loads i.e., at 0 load, 25%, 50%, 75% and 90%.

4. RESULTS AND DISSCUSION

Engine performance analysis:

The performance of an engine is mainly studied with the help of the operating conditions. The characteristics obtained by operating the single cylinder diesel engine with the blends of palm kernel oil and eucalyptus oil are discussed below. T

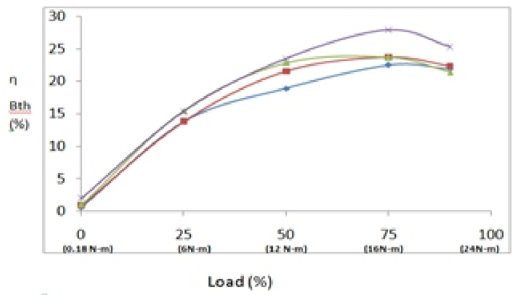
he obtained results are compared with the results obtained when operated with diesel, palm kernel +diesel mixture, eucalyptus oil + diesel mixture at various compression ratios.The below indicated graphs are used to study various characteristics of engine like brake thermal efficiency, mechanicalefficiency, engine outlet temperature

a.Brake thermal efficiency (η bth) %:

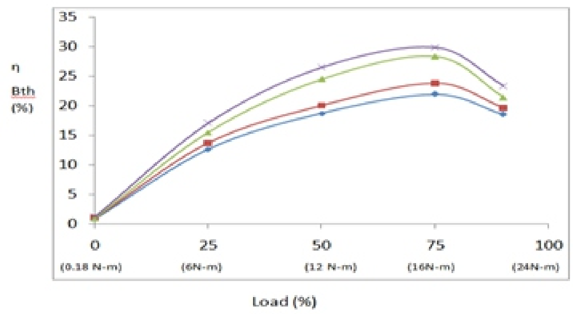
The variation in brake thermal efficiency with variation in loads at different compression ratios for different blends is shown below.

Load(%)	PKE10 CR13	PKE10 CR16	PKE10 CR19	PKE30 CR13	PKE30 CR16	PKE30 CR19	PKE50 CR13	PKE50 CR16	PKE50 CR19	DIESEL CR13	DIESEL CR16	DIESEL CR19
0	0.59	0.855	0.86	0.864	1.02	0.856	0.96	0.96	0.96	1.99	1.21	0.87
25	13.77	12.63	13.47	13.79	13.65	13.79	15.47	15.47	15.47	15.33	17.07	19.24
50	18.89	18.69	20.81	21.52	19.99	20.34	22.81	24.48	22.81	23.45	26.49	26.68
75	22.48	21.94	21.07	23.68	23.78	23.98	23.66	28.32	23.66	27.91	29.86	24.34
90	21.87	18.48	19.48	22.31	19.61	19.07	21.39	21.39	21.39	25.27	23.31	21.28

Table4: comparison of brake thermal efficiency of blends with diesel Graph1: LOAD (%) Vs BRAKE THER MAL EFFICIENCY at compression ratio 13



_Palm kernel oil 90+eucalyptus 10
_ Palm kernel oil70+ eucalyptus 30
_ Palm kernel oi50 + eucalyptus 50
_ DIESEL



Graph2:LOAD (%) Vs BRAKE THERMAL EFFICIENCY at compression ratio 16

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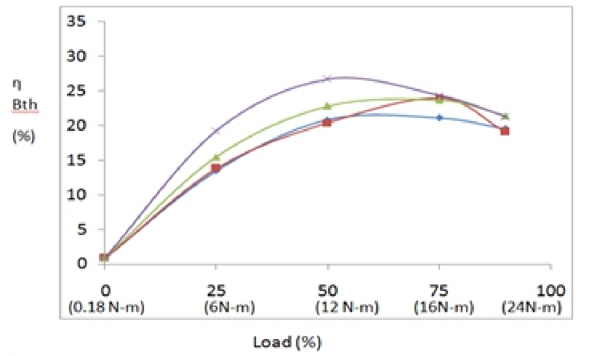


Graph3: LOAD (%) Vs BRAKE THERMAL EFFICIENCY at compression ratio 19 :

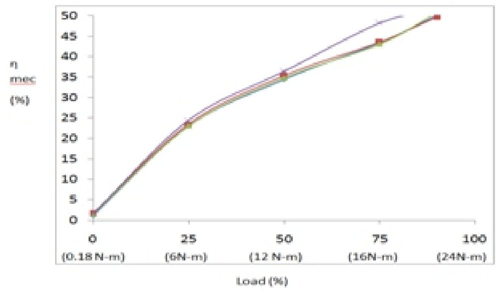
As shown in the above graph sat all compression ratios the brake thermal efficiency of diesel is higher than the remaining blends but at the full load at same compression ratio the efficiency is nearer to the efficiency obtained by remaining blends. Next to diesel PKE50 (palm kernel 50+ eucalyptus 50) is higher. This is mainly due to the presence of high volatile eucalyptus oil in the the blend used. Eucalyptus oil mainly consists of cineole. Cineole decomposes easily at low temperature it releases intermediate compounds in a heavy manner as soon as the fuel is injected. The reduced viscosity leads to improved atomization, fuel vaporization and combustion. Eucalyptus oil presence increases the ignition delay period and it causes the heavy accumulation of fuel which results in heavy heat release and higher brake thermal efficiency and high cylinder pressure.

b.Mechanical efficiency:

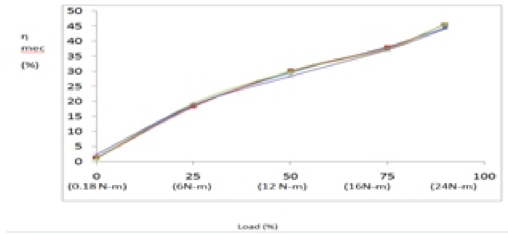
The variation in mechanical efficiency with variation in loads at different compression ratios for different blends is shown below.

Load (%)	PKE10 CR13	PKE10 CR16	PKE10 CR19	PKE30 CR13	PKE30 CR16.	PKE30 CR19	PKE50 CR13	PKE50 CR16.	PKE50 CR19	DIESEL CR13	DIESEL CR16.	DIESEL CR19
0	1.08	1.43	1.09	1.65	1.26	2.01	1.41	1.16	0.82	1.48	2.47	1.02
25	23.03	18.7	17.56	23.51	18.26	18.36	23.07	19.34	18.84	24.42	18.89	16.83
50	34.45	29.54	28.01	35.38	30.11	28.91	34.78	29.95	30.65	36.42	28.39	26.62
75	43.45	38.11	35.77	43.62	37.87	35.11	43.11	37.38	39.05	48.24	37.08	34.84
90	50.05	44.51	43.9	49.66	45.6	42.12	50.74	45.8	46.63	51.41	44.2	42.53

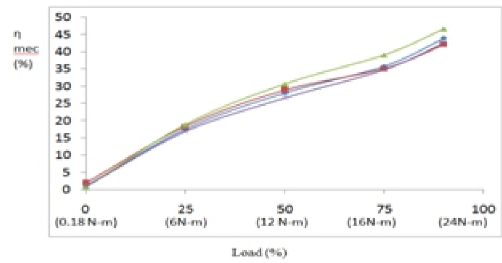
Table5: comparison of mechanical efficiency of blends with diesel



Graph4: LOAD (%) Vs MECHANICAL EFFICIENCYat compression ratio 13



Graph 5:LOAD (%) Vs MECHANICAL EFFICIENCY at compression ratio 16



Graph6:LOAD (%) Vs MECHANICAL EFFICIENCYat compression ratio 19

_Palm kernel oil 90+eucalyptus 10
_ Palm kernel oil70+ eucalyptus 30
_ Palm kernel oi50 + eucalyptus 50
_ DIESEL

As shown in the above graphs the mechanical efficiency of diesel is very high at compression ratio 13 when compared to the remaining experimental blends at all loads. At compression ratio s 16, 19 the mechanical efficiency is equal for all theexperimental fuels and diesel at all the loads.

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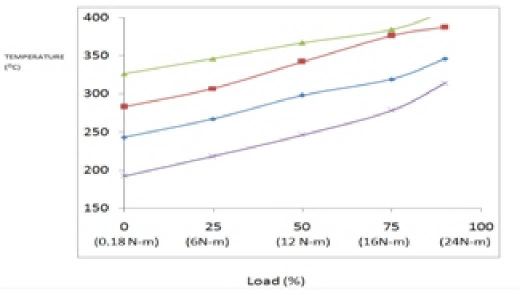
Comparatively at compression ratio 19 at full load efficiency for PKE50 is higher than remaining experimental blends.Mechanical efficiency is the result of both brake thermal efficiency and indicated thermal efficiency. The brake thermal efficiency and indicated thermal efficiency of diesel is high than remaining blends. Next to the diesel PKE50 blend is having higher efficiency. Mechanical efficiency of diesel and the experimental blends are almost equal with a slight variation.

c.Exhaust Gas temperature:

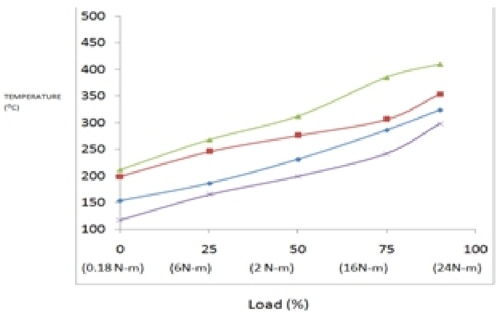
The variation of exhaust gastemperature with variation in load for different blends of eucalyptus oil and palm kernel oil at different compression ratios are shown below.

Load (%)	pke10 cr13	pke10 cr16	pke10 cr19	pke30 cr13	pke30 cr16.	pke30 cr19	pke50 cr13	pke50 cr16.	pke50 cr19	diesel cr13	diesel cr16	diesel cr19
0	243	154	213	283	199	254	326	212	274	192	117	182
25	267	186	257	307	246	287	346	268	310	218	165	217
50	298	231	303	342	276	348	367	312	369	246	199	252
75	319	286	356	376	306	387	384	385	404	278	242	294
90	346	324	378	387	354	410	408	410	425	314	298	351

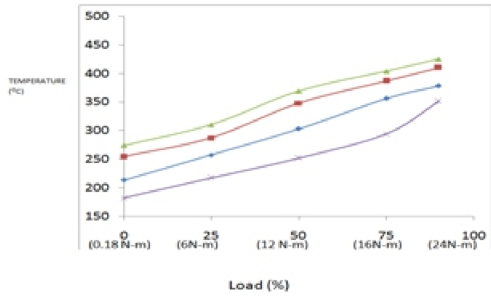
Table 6: Comparision of exhaust gas temperature of diesel with blends



Graph 7: LOAD (%) Vs outlet water temperature at compression ratio 13



Graph8:LOAD (%) Vs outlet water temperature at compression ratio 16



Graph 9:LOAD (%) Vs outlet water temperature at compression ratio 19

_Palm kernel oil 90+eucalyptus 10
_ Palm kernel oil70+ eucalyptus 30
_ Palm kernel oi50 + eucalyptus 50
_ DIESEL

As shown in the above graphs the exhaust temperature of diesel is lower than remaining the experimental blends. This is mainly due to the presence of eucalyptus oil in the blends which ha s lower cetane number and high percentage of oxygen which leads to longer ignition delay and rapid combustion which results in higher temperature and high cylinder pressure. Next to diesel PKE10 is having lower exhaust temperature at all the compression ratios. It has lower temperature compared to remaining blends since the quantity of eucalyptus oil present in this blend is lesser than remaining blends.

5.EMISSION ANALYSIS:

a.Hydro carbon (hc) emissions:

The variation of hc emissions with variation in load for different blends of eucalyptus oil and palm kernel oil at different compression ratios are shown below.

load (%)	pke10 cr13	pke10 cr16	pke10 cr19	pke30 cr 13	pke30 cr16.	pke30 cr19	pke50 cr13	pke50 cr16.	pke50 cr19	diesel cr13	diesel cr16	diesel cr19
0	80	28	78	40	18	36	30	10	26	90	55	80
25	91	46	83	68	28	74	45	18	60	148	74	120
50	130	75	107	92	47	98	67	32	84	194	98	180
75	207	124	223	194	76	183	146	73	141	248	143	249
90	322	212	312	279	148	248	238	135	226	332	220	321

Table7: comparison of HC emissions

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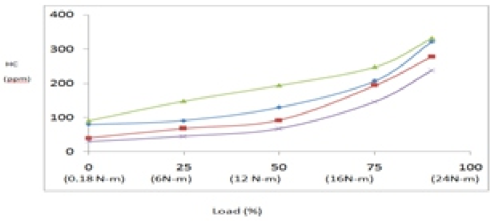
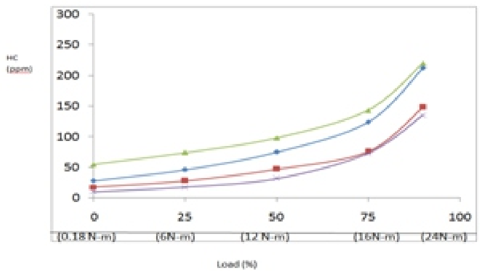
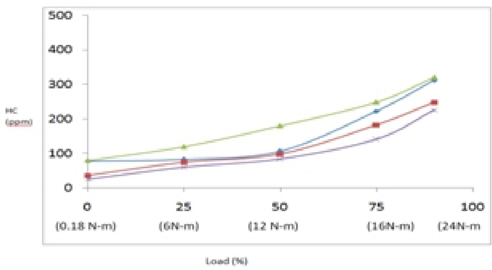


Graph10:LOAD (%) Vs HC EMISSION at compression ratio 13



Graph 11:LOAD (%) Vs HC EMISSION at compression ratio 16



Graph 12:LOAD (%) Vs HC EMISSION at compression ratio 19

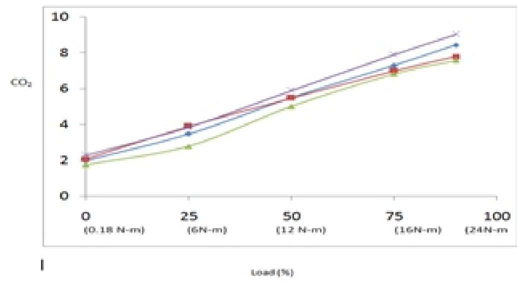
As shown in the above graphs the hydrocarbon emissions of diesel are higher than all the experimental blends. At all compression ratio at every load diesel is having the high emission of hydro carbons. In our present experimental blends PKE10 is having higher HC emissions. HC emissions for bio fuels are low because of the complete combustion of the fuel. As the ignition period lengthens due to the lower cetin number at some areas of the combustion chamber the mixture becomes too leaner which leads to the lower HC emissions.

Carbon dioxide (co2) emissions:

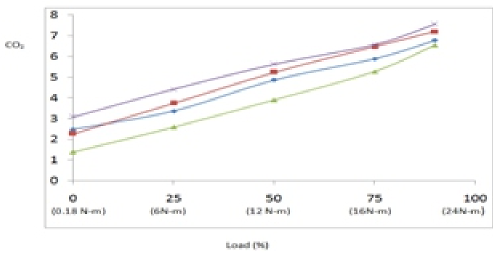
The variation of carbon dioxide emissions with variation in load for different blends of eucalyptus oil and palm kernel oil at different compression ratios are shown below.

Load (%)	PKE10 CR13	PKE10 CR16	PKE10 CR19	PKE30 CR13	PKE30 CR16	PKE30 CR19	PKE50 CR13	PKE50 CR16	PKE50 CR19	DIESEL CR13	DIESEL CR16	DIESEL CR19
0	1.98	2.48	2.89	2.08	2.28	3.07	2.29	3.09	3.31	1.75	1.4	2.77
25	3.48	3.36	4.12	3.89	3.75	4.24	3.84	4.42	4.49	2.79	2.6	4.12
50	5.49	4.87	5.32	5.47	5.24	5.49	5.9	5.63	6.4	5	3.9	5.32
75	7.29	5.89	7.21	6.98	6.89	7.48	7.89	6.57	8.24	6.81	5.27	6.76
90	8.42	6.48	8.98	7.78	7.21	9.12	9.02	7.56	9.64	7.56	6.54	8.486

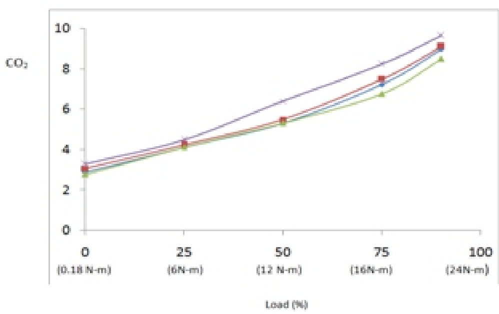
Table8 : variation of CO2 emissions



Graph13:LOAD (%) Vs CO2EMISSION at compression ratio 13



Graph 14:LOAD (%) Vs CO2EMISSION at compression ratio 16



Graph15:LOAD (%) Vs CO2EMISSION at compression ratio 19

As shown in the above graphs the carbon dioxide emission of all the experimental fuels are higher when compared to diesel.

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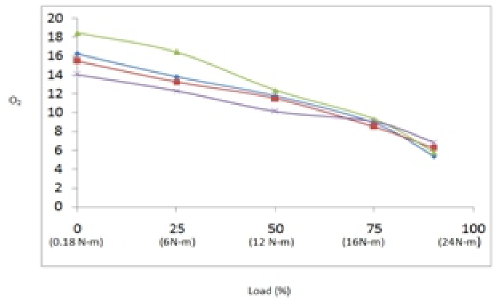
This is mainly because of the oxygen enrichment in the eucalyptus oil and addition of palm kernel oil leads to the oxidation of CO produced during the exhaust process. Rather than diesel PKE10 is having lesser emissions in the present experimental fuels.

OXYGEN (O2) EMISSIONS:

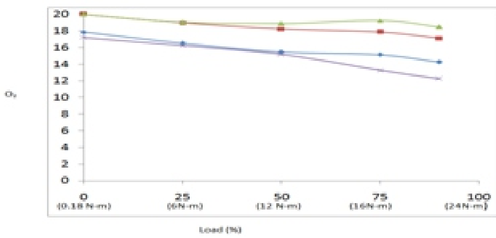
The variation of oxygen emissions with variation in load for different blends of eucalyptus oil and palm kernel oil at different compression ratios are shown below.

Load (%)	PKE10 CR13	PKE10 CR16	PKE10 CR19	PKE30 CR13	PKE30 CR16.	PKE30 CR19	PKE50 CR13	PKE50 CR16.	PKE50 CR19	DIESEL CR13	DIESEL CR16	DIESEL CR19
0	16.23	15.36	15.56	18.46	20.48	15.64	14.03	15.73	15.22	15.46	20.46	16.48
25	13.8	13.36	13.23	16.42	18.86	13.44	12.301	13.31	12.88	13.24	19.04	14.7
50	11.73	11.33	10.76	12.36	15.89	11.36	10.14	11.44	10.48	11.48	18.89	11.45
75	8.87	9.46	7.74	9.3	12.86	8.06	9.06	9.61	6.43	8.49	19.24	8.07
90	5.4	5.65	4.13	5.79	10.46	4.24	6.81	6.95	3.63	6.25	18.48	5.01

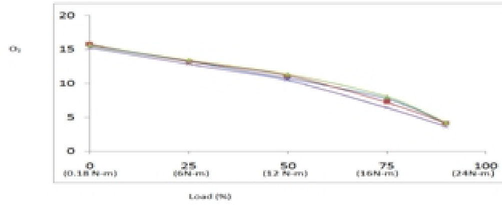
Table9: Variation of O2 emissions aph



16: LOAD (%) Vs O2EMISSION at compression ratio 13



Graph 17: LOAD (%) Vs O2EMISSION at compression ratio 16



Graph 18:LOAD (%) Vs O2EMISSION at compression ratio 19

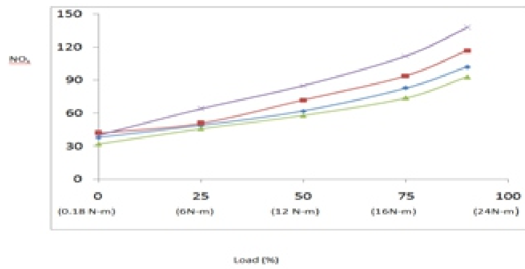
As shown in the above graphs the oxygen emitted by diesel is higher when compared to remaining experimental fuels. In eucalyptus oil the oxygen content is more and the ignition lag is long so the combustion takes place completely and the oxygen present is used for the oxidation of CO. PKE 10 has higher oxygen emissions in our considered blends at 13 compression ratio. But at compression ratio 13 the mixture is too leaner. So the compression ratio prefered is 16. At compression ratio 16 net to diesel PKE30 has higher oxygen emissions.

NITROUS OXIDE EMISSIONS:

The variation of nitrous oxide emissions with variation in load for different blends of eucalyptus oil and palm kernel oil at different compression ratios are shown below.

Load (%)	PKE10 CR13	PKE10 CR16	PKE10 CR19	PKE30 CR13	PKE30 CR16.	PKE30 CR19	PKE50 CR13	PKE50 CR16.	PKE50 CR19	DIESEL CR13	DIESEL CR16	DIESEL CR19
0	38	28	36	42	39	46	40	52	62	32	12	24
25	49	44	66	51	52	74	64	65	89	46	32	56
50	62	56	89	72	68	98	85	87	106	58	44	83
75	85	78	112	94	84	120	112	128	134	74	54	108
90	102	108	134	117	108	153	138	156	166	93	66	127

Table10: variation of NOx emissions



Graph 19:LOAD (%) Vs NOxEMISSION at compression ratio 13

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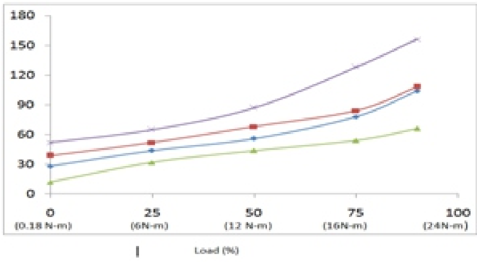
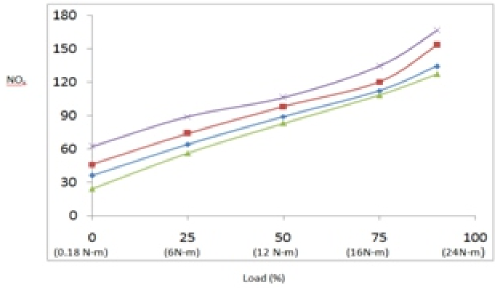


Graph 20: LOAD (%) Vs NOxEMISSION at compression ratio 16



Graph 21:LOAD (%) Vs NOxEMISSION at compression ratio 19

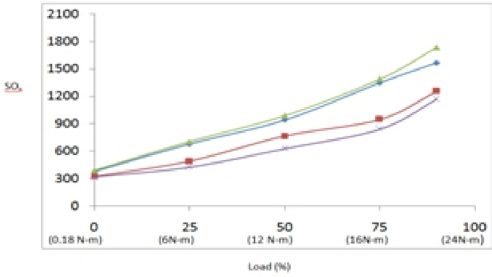
As shown to experimental fuels. This is mainly because the heavy existence of oxygen in bio fuels and further more existence of oxygen in eucalyptus oil. Another reason for higher emission of NOX is lower Cetane number of eucalyptus oil lengthens the ignition delay period. In the above graphs nitrous oxide emissions of diesel is lesser when compared.

SULPHUROUS OXIDE EMISSIONS:

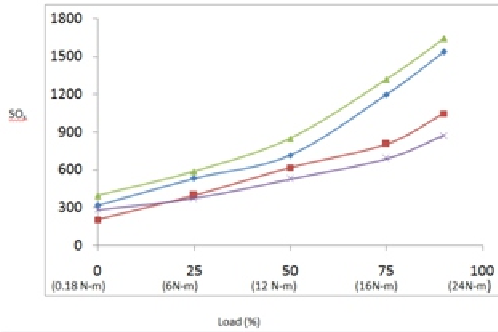
The variation of oxygen emissions with variation in load for different blends of eucalyptus oil and palm kernel oil at different compression ratios are shown below.

Load (%)	PKE10 CR13	PKE10 CR16	PKE10 CR19	PKE30 CR13	PKE30 CR16.	PKE30 CR19	PKE50 CR13	PKE50 CR16.	PKE50 CR19	DIESEL CR13	DIESEL CR16	DIESEL CR19
0	376	316	312	326	205	248	315	283	249	388	394	548
25	678	532	769	488	398	571	425	371	307	704	586	968
50	942	714	1147	762	615	752	628	527	486	989	848	1346
75	1346	1198	1537	948	806	1365	842	689	684	1387	1318	1876
90	1564	1538	1854	1256	1046	1796	1168	873	1247	1734	1640	2146

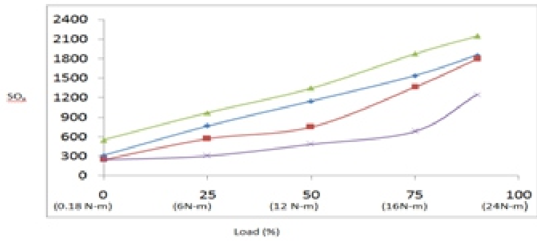
TABLE11: Variation of SOx emission



Graph 22:LOAD (%) Vs SOXEMISSION at compression ratio 13



Graph 23:LOAD (%) Vs SOXEMISSION at compression ratio 16



Graph 24:LOAD (%) Vs SOXEMISSION at compression ratio 19

As shown above sulphorus oxide emission of diesel is high at all compression ratios at all the loads. In our experimental fuels PKE10 is having higher emissions and PKE 50 is having lower emissions.

_Palm kernel oil 90+eucalyptus 10
_ Palm kernel oil70+ eucalyptus 30
_ Palm kernel oi50 + eucalyptus 50
_ DIESEL

6.CONCLUSION:

a.Performance analysis:

» Brake thermal efficiency of all the considered blends at all the compression ratios for minimum loads is equal, as the load increases efficiency increases and diesel has higher efficiency compared to remaining blends. Compared to remaining compression ratios at Cr 16 maximum efficiency is obtained but as the load approaches to full load the efficiency gradually decreases.

» Mechanical efficiency is higher at compression ratio 13 when compared with remaining compression ratios. At Cr13 the efficiency of diesel is higher but at remaining compression ratios with minute variations PKE50 (palm kernel50+eucalyptus50) has higher mechanical efficiency when compared to diesel.

» Exhaust gas temperature of diesel is lower than all the considered experimental fuels. Comparatively next to diesel PKE10 has lower exhaust gas temperature.

b.EMISSION ANALYSIS:

» HC emissions are high for PKE10 compared to the remaining experimental fuels. In overall at compression ratio 13 HC emissions are high for all the blends. Compared to all the considered fuels PKE50 emits lower HC emissions than diesel at all the compression ratios.

» Carbon dioxide emissions are higher at compression ratio 19 for all the considered blends. As the compression ratio increases CO2 emissions increases. At Cr13 lower CO2emissions are observed. As the load increases the emission increases. PKE50 has higher emissions compared to all the considered fuels.

» At minimum loads the oxygen emissions are high, as the load increases oxygen emissions decreases. Oxygen emitted by PKE30 (palmkernel70+eucalyptus30) is almost equal to the oxygen content emitted by diesel at all the loads for all the compression ratios. PKE50 emits the least oxygen emissions.

» As the compression ratio increases the emissions increases. Diesel emits higher SOx emissions when compared to the considered experimental fuels.

The results proved that the blending of palm kernel oil with eucalyptus oil can be used as a alternative fuel in diesel engine by completely elimination of diesel. The emissions and performance are of considerable range for all blends especially for PKE50 blend. It can be concluded that Palm kernel 50+eucalyptus 50 can be used in diesel engine without any major modifications to the engine.

7.FUTURE SCOPE OF WORK:

Biodiesel as an alternative fuel has may advantage. Even though initial production cost is high but feed stock diversity and multi feed stock production leads an important role in reducing the production cost. Following are the aspects to be considered before implementing bio fuels in India.

» Government may consider providing support to the activities like production of oil from eucalyptus leaves, palm kernel seeds and various waste sources.

» Legal frame work should be there to enforce regulation on bio fuels.

» Blends prepared for this project work were utilized within short time span. Thus long term stability of blends was not studied. Sothere is scope for study of long term stability of blend.

» At the compression ratio increases Nox emissions increases. At Cr 19 the Nox emissions are higher, as the load increases the Nox emissions increases. For PKE50(palm kernel50+eucalyptus50) Nox are higher than remaining experimental fuels.

» Technique of transesterification can be extended to various waste and non-edible vegetable oils. Further investigation can be carried out to prepare ethyl ester from various waste and non edible vegetable oils and to conduct various engine tests.

» Performance and emission tests can be carried out on multi cylinder generator engines and surface transport engines like car, bus etc.,

» Further studies can also be carried out on material compatibility, storage and utilization of by product from bio fuel.

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