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PERFORMANCE AND EMISSIONS EVALUATION OF DIRECT INJECTION CI ENGINE FUELLED WITH BLENDS OF BIODIESEL EXTRACTED FROM MAHUA OIL AND DIESEL

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***Abstract*— As the population is increasing continuously and there by the vehicles are also increasing so to overcome problems of more consumption of fossil fuels and more emissions of unburnt hydrocarbons, carbon mono oxide and particulate matter, there is a need of alternative fuels that will reduce the consumption of fossil fuels and harmful emissions. here we are making observations on blending of esterified bio diesel into pure diesel. Due to having more demand of edible oil in food industries we are using a one of nonedible oils and that is mahua oil. As the consumption of fossil fuels increases, the concentration of carbon die oxide increases which is a main cause of global warming. In recent years due to having a large demand of fossil fuels the stocks are going to end and in future there will be a crises if we will not be having any alternative solution .in future biodiesel production from non-edible oil like mahua oil will be an suitable alternative as it is considered as potential alternative of the bio diesel production. The parameters like temperature of reaction, catalyst used and oil alcohol molar ratio are optimized. Mainly carbon dioxide has the responsibility for global warming and its concentration is increasing as the fossil fuels are being used year by year. So we will have to change our way of using fossil fuels and we have to make more alternatives so that the use of fossil fuels can be minimized. These alternatives should be originated from non-conventional energy resources .in India where there is more number of non-conventional energy resources, so it is easy to make an alternative which will be extracted from non-conventional energy resource. Diesel fuel which we are using widely in our vehicles can be continued by mixing some kind of blending extracted from any oil likewise here we are making biodiesel by blending oil extracted from mahua oil. So our contribution to our nation will be greater if we make some kind of alternative which will be based on some kind of renewable energy resources.**

***Index Terms*— Emission behavior, CI Engine, Mahua oil, Bio fuels.**

I. INTRODUCTION

Agricultural machinery and commercial transportation are highly dominated by diesel engines because great efficiency because it has great efficiency and ease of operation .the production of automotive vehicle is increasing at the high rate because of the rapid industrialization the economy of India and china is growing very fast and the same time and at the same time this growth is affecting the environment badly. India and china are the hub for fossil oil consumption and this consumption contributes to global warming .

Renewable energy is an alternate for fossil fuel .plant oil is renewable and can be produced easily in rural area so it may be used as a good alternative to diesel oil. Today it has little important but in the near future it can be significant just as other fossil fuels.

The potential alternative fuel can be seen as-

- Alcohols (Methanol and Ethanol)
- Liquefied Petroleum Gas (LPG)
- Compressed Natural Gas (CNG)
- Hydrogen
- Vegetable oils

Oil extracted from the vegetables are eco-friendly and can be used as an alternative of diesel .on blending these kind of vegetable oils, the emissions will be less and all the vegetable oils are bio degradable .thus in every aspect if we see towards these vegetable oils in the form of alternative to diesel oil then we will find that use of these oils in diesel will give us a great satisfaction and we will be contributing also in environment protection activities. vegetable oils like Sunflower oil, Soybean oil, Rapeseed oil, Corn oil, Linseed oil, Peanut oil, Rice- bran oil, Cottonseed oil , Honge oil, Palm oil etc are being tested all over the world and performance is being evaluated in diesel engines.Our present study is based on mahua oil.

A. MAHUA OIL

Vegetable oils have a friendly charcter with the environment so vegetable oils can be used as an alternative in diesel engine. Diesel oil has a major role in the emission of harmful gases like carbon di oxide ,carbon mono oxide and other more .so there is a need to move a substitute of diesel fuel.the emissions from the fossil fuels make a greater effect on atmosphere so we shall have to draw our attention towards these eco friendly resources.diffrent kind of disasters like globel warming ,green house effect and all other which are harmful to our atmosphere and our life are also affected by using these fossil fuels,we can make vegetable oils as a strong alternative of diesel oil. various kind of vegetable oil are being tested for this purpose.

We are more excited when we see the results in the direction tested with edible oils but in india there is a high demand of edible oils for various purposes so we are in need of making this alternative by using non edible oil like jatropha oil,neem oil,mahua etc. when we evaluate the performance of CI engine with these kind of alternative ,we find an increment in responsible factors for good efficiency.

Fig 1.1. Mahua Oil

Maduca indica is a botanical name of mahua .we got madhuca indica oil from the trees of two major species namely madhuca latifolia and madhuca longifolia .these can be founded semi arid ,tropical and sub tropical areas in altitude up to1200-1300 meter .these trees have 1 to 5 tiny seeds .the material fallen from the tree is picked and rind is removed by hand and seed is decorticated by beating with stones.

1) USES OF MAHUA

It is cultivated in warm and humid regions for its oleaginous seeds (producing between 20 and 200 kg of seeds annually per tree, depending on maturity), flowers and wood. The fat (solid at ambient temperature) is used for the care of the skin, to manufacture soap or detergents, and as a vegetable butter. It can also be used as a fuel oil. The seed cakes obtained after extraction of oil constitute very good fertilizer. The flowers are used to produce an alcoholic drink in tropical India. This drink is also known to affect the animals. Several parts of the tree, including the bark, are used for their medicinal properties. It is considered holy by many tribal communities because of its usefulness.

The alkaloids in the press cake of mahua seeds is reportedly used in killing fishes in aquaculture ponds in some parts of India. The cake serves to fertilise the pond, which can be drained, sun dried, refilled with water and restocked with fish fingerlings

2) Mahua Flowers

The mahua flower is edible and is a food item for tribals. They use it to make syrup for medicinal purposes. They are also fermented to produce the alcoholic drink mahua, a country liquor. Tribals of Bastar in Chhattisgarh and peoples of Western Orissa, Santhals of Santhal Paraganas (Jharkhand), Koya tribals of North-East Andhra Pradesh, Bhil tribal in western Madhya Pradesh and tribals of North Maharashtra consider the tree and the mahua drink as part of their cultural heritage. Mahua is an essential drink for tribal men and women during celebrations. The main ingredients used for making it are chhowa gud (granular molasses) and dried mahua flowers.

Fig 1.3. Mahua Flowers

In many parts of Bihar, such as villages in the district of Siwan, the flowers of mahua tree are sun-dried; these sun-dried flowers are ground to flour and used to make various kinds of breads.

Fig 1.4(a). Dry Mahua

Fig 1.4(b). Dry Mahua

B. OBJECTIVE OF THIS WORK

A problem of fuel crises and environment issues draw our attention towards a suitable which is having a reliable and permanent solution of our problem. Vegetable oils blends may be suitable substitute having properties like diesel fuel.

For making this kind of biodiesel we divided our work into these phases.

- We select the edible oil Madhuca Indica or Mahua oil was selected for this work.
- Characterization of various physical, chemical and thermal properties of vegetable oil and prepared small batches of methyl ester from the above oil Production of methyl esters for the above-mentioned oil.
- Characterization and comparison of various physical, chemical and thermal properties of methyl ester oil with respect to diesel.
- Now we Collect the data regarding performance and emission for various loads under various conditions.

II. LITERATURE REVIEW

Sudheer Nandi stated- We can extract 800-850ml esterified mahua oil from 1000ml mahua oil during esterification. As the percentage of esterified mahua oil is increased in diesel it will go towards more viscosity and also increases the cetane number of blend mixture. He observes a slight increase in brake thermal efficiency and a decrease in brake specific fuel consumption on having a mixture of 75 percent of esterified mahua oil. He also observes less emission of particulate matter on a blend of mahua oil.this is observed by taking a tissue paper at the exhaust. Ha also tells that 200 bar injection pressure is optimum for better results.

Mr. P.K kurve and Rupesh J Yadav have considered that To overcome the problems caused by using fossil fuels in vehicles , it is necessary to use renewable energy resources up to some extent so that consumption of fossil fuels can be reduced .in this paper mr.P.K. Kurwe and mr. Yadav has made a blending of some amount bio diesel extracted from mahua oil into pure diesel and they made various observations by doing experiments and find a relief in performance and emissions of IC engine. He observes that on reducing the concentration of blend there is an increase in brake thermal efficiency.BTE highest for a blend B27 is 28% and lowest for B100 is 22%.

Rao-professor at KIT Warangal Telangana He conducted his experiments with B20 blend of biodiesel extracted from mahua oil and find that BTE was slightly less in comparison with pure diesel.Emissions of CO,HC smoke were decreased on blending the bio diesel in a blend of B20 He also observed that methyl ester of mahua oil gives better result in comparison with ethyl esters of mahua oil.

H Rahman, Prakesh jena and S.S jadhav, On considering the difficulties arising from more consumption of fossil fuels into vehicles mr H Rahman,Prakash jena and S.S jadhav draws our attention towards bio diesel blending extracted from mahua and simarouba(50:50) into diesel.they did their experiments on a 10.3 KW single cylinder water cooled direct injection diesel engine and observed various results.

They found a slight reduction in BTE by 1.48 to 3.22 percent in blend mixture using blends B10 and B20 biodiesel in comparison with HSD diesel. They also found an increase in BSEC by 2.49% to 5.62% and 4.44 to 5.62% in a blend of B10 and B20. The emissions of HC and CO was found to be decreased by 10.2%,21.8% etc in comparison with diesel. Overall blend B10 was found to be reliable.

H.M dharmadhikari,P.R kumar and S srinivasa, In recent years due to having a large demand of fossil fuels the stocks are going to end and in future there will be a crises if we will not be having any alternative solution so here mr. H.M dharmadhikari ,mr P.R kumar and S srinivasa shows us an alternative solution in the form of blending of biodiesel in diesel. they made their experiments on a kirloskar AV-1 single cylinder diesel engine by doing blending at various injection pressures and performance parameters are analysed, The observe that the injection pressure of 200 bar is optimum in the range of 180-220 bar .the barke thermal efficiency has a decrement of 6% for all blends in comparison with diesel CO and HC emissions were less and NO emission was also observed reduced by 39% for B10 and 28% for B20 in comparison with diesel engine. BSFC was higher at entire load range for all blends as compare to conventional diesel due to its lower heating value.

Mr. PK Rathore,M.P Singh and Sugandha Singh, On seeing various difficulties and problems arising from more consumption of fossil fuels mr.PK rathore,M.P singh and sugandha agnihotri evaluated the performance of CI engine using biodiesel extracted from mahua oil in diesel .they find various results at different amount of blend ,different injection pressures and at different exhaust temperatures. They

conducted their experiments at speed 1500 rpm compression ratio 17.5:1 and injection timing before 24 degree before TDC. As they are going to increase the blend from B0 to B100 , a decrement is observed in BTE. The performance of engine with blend fuel B30 was found to be best of all blends but power output ,BSFC,BTE,EGT observed as 3% more,9% more,12% more and 0.5 % less for a blend of B30 at 800 degree temp. and 23010 kpa pressure They also find that with increase in fuel temperatures and injection pressures ESFC decreases at all blends but it was found a little increase from B30 to B100 at aperticular temperature and pressure.

III. SELECTED OIL FOR PRESENT WORK

In all vegetable oils we have selected a non edible oil for our experimental investigation. Mahua oil is being considered here for the calculation. Government promotes the cultivation of these seeds by utilizing wastelands.thus government is also encouraging us for doing something like this .In this way mahua oil we can find easily on our lands thus using mahua oil in making bio diesel we will never have any kind of difficulty related to its production.

Table3.1: Annual Production of Some Edible/Non-edible oil Seeds in India

Type	Production (MT)	Oil %
Neem	500	30
Karanja	250	30-40
Kusum	90	38
Pilu	55	37
Ratanjot	-	30-40
Mahua	500	35-45
Jajoba	-	50
Bhikal	-	37
Undi	05	50-80
Thumba	150	31

The oil production capacity is directly proportional to the present demand in market.

Table No: 3.2 Madhuca Indica Oil properties

S.No.	Proper ty	Refin ed	Raw 1	Raw 2
1	Moisture & insoluble Impurities, % by mass	0.10	0.35	.50m
2	Color in ¼ in cell on the Lovibond scale (+5R)	10	55	55
3	Refractive index at 40^0 C	1.456	--	1.46
4	Specific Gravity at $90/30^0$ C	0.86	--	0.87
5	Saponification value	188-198	187-197	187-197
6	Iodine value	58-71	58-71	58-71
7	Unsaponifiable matter, %by max	3	4	4
8	Acid value max	0.5	21	Above 20
9	Titre (0^0 C) Min	41	41	41
10	Flash point (PMC)	255	105	105

IV. EXPERIMENTAL SETUP

A. SELECTION OF ENGINE

Since number of vehicles are increasing continuously and the stock of fossil fuels is limited so we have to draw our attention towards using an alternative fuel which is having unlimited stock .here we used the mahua oil for making bio diesel .For the present work the tests are being conducted on single cylinder ,four stroke air cooled diesel engine coupled with electrical dynamometer test. The figure shows the specifications of engine

Table.4.1 Engine specifications

Engine Type	Four stroke, stationary, constant
Make	Kirloskar
Model	TAF1
Maximum Power	4.5 kW @ 1500 RPM
Maximum Torque	29 N-m @ 1500 RPM
Bore	87.5 mm
Stroke	110 mm

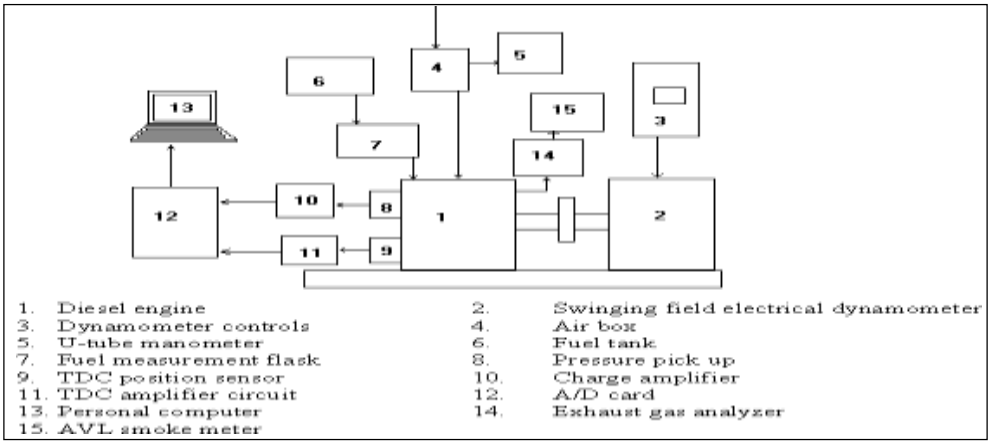

Fig. 4.1 Layout of engine test rig

To measure the brake power of engine dynamometer is used and we are using a smoke meter to measure the particulate matter and emission.

Test Procedure:

When we are going to start the experiments, all the equipments are being calibrated according to the guidelines .now methyl ester is used as fuel in the engine .for every fuel change, fuel lines are cleaned and we left the engine undisturbed for almost 30-40 minutes to stabilize on new conditions. The following measurement was made at various loads.

- Fuel consumption
- Air flow rate
- Engine output
- In cylinder pressure data
- Engine emission

Error analysis:

The error associated with various primary experimental data and calculation parameters are detailed in table.

Table 4.2 Summary of estimated uncertainties

Parameters	Uncertainty (%)
Reaction temperature	0.248
Exhaust gas temperature	0.42
Pressure	2.0
Brake thermal efficiency	0.32
UBHC	5.2
CO	5.1
NOx	5.1
Smoke intensity	5.1

V. RESULTS AND DISCUSSIONS

The results of observations on diesel engine with methyl esters of Madhuca Indica (mahua) oil (MOME) and their diesel blends are being discussed. The effects of retardation of injection timing on combustion parameters, performance and emissions with 20% blends of methyl ester are also discussed.

A. COMBUSTION PARAMETERS AT STANDARD INJECTION TIMING

This section describes the effects of percentage of methyl ester in the blend on combustion characteristics viz. ignition delay, peak pressure and heat extraction rate based on experimental results.

1) Ignition Delay (ID)

The ignition delay of various blends of mahua methyl ester at different loads is also being compared with diesel and is shown in Figure 5.1. It can been seen that the ignition delay of methyl ester and its blends is significantly lower than that of diesel and decreases with increase in the percentage of methyl ester in the blend and neat ester record the lowest ignition delay when compared to their blends and diesel. For example, the decrease in delay at full load (4.4kW) is 0.25%, 0.44%, 0.65%, 0.98%, 1.33% for 22% MOME, 40% MOME, 60% MOME, 80% MOME and MOME respectively.

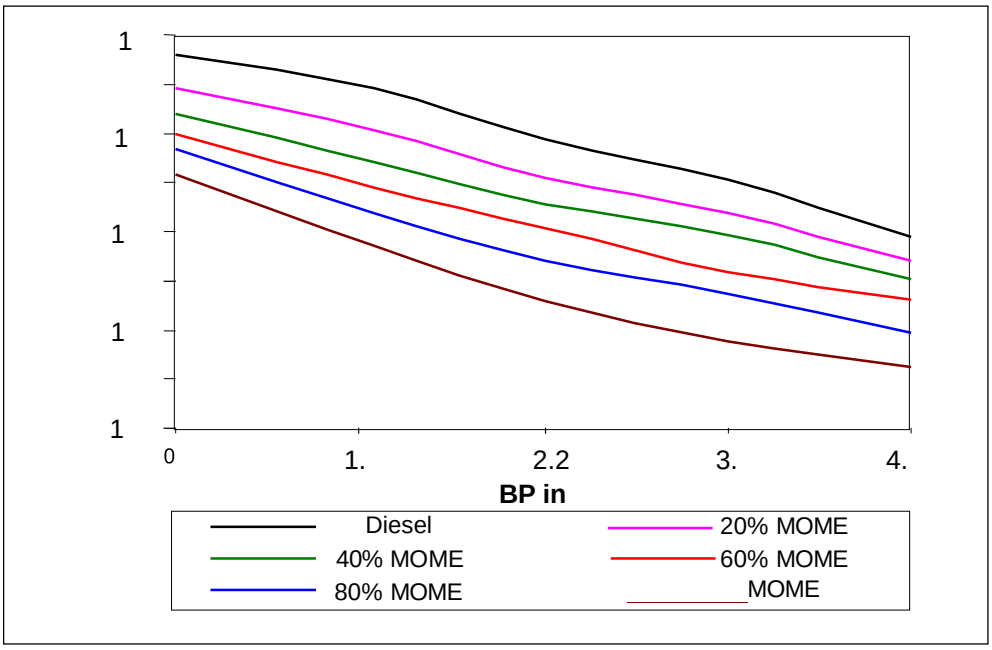

Fig.5.1: Comparison of ignition delay for MOME/diesel blends

2) Variation of Cylinder Pressure

Figure 5.2 show the variation of cylinder pressure with crank angle at rated power (4.4kW) for diesel, blends of 20%, 40%, 60% and 80% and 100% of MOME,. All the fuels have shown the same trend except for slight changes in values of pressure at various crank angles. There are three distinct regions: Region I (From the start of combustion to 40 bTDC): The cylinder pressure is seems to be higher for methyl ester and its blends compared to diesel. In this region, the cylinder pressure increases with the increase in percentage of methyl ester in the blend. This is due to the lower ignition delay of methyl ester and its blends. The combustion starts earlier and the motion of the piston towards TDC also helps the rise in gas pressure.

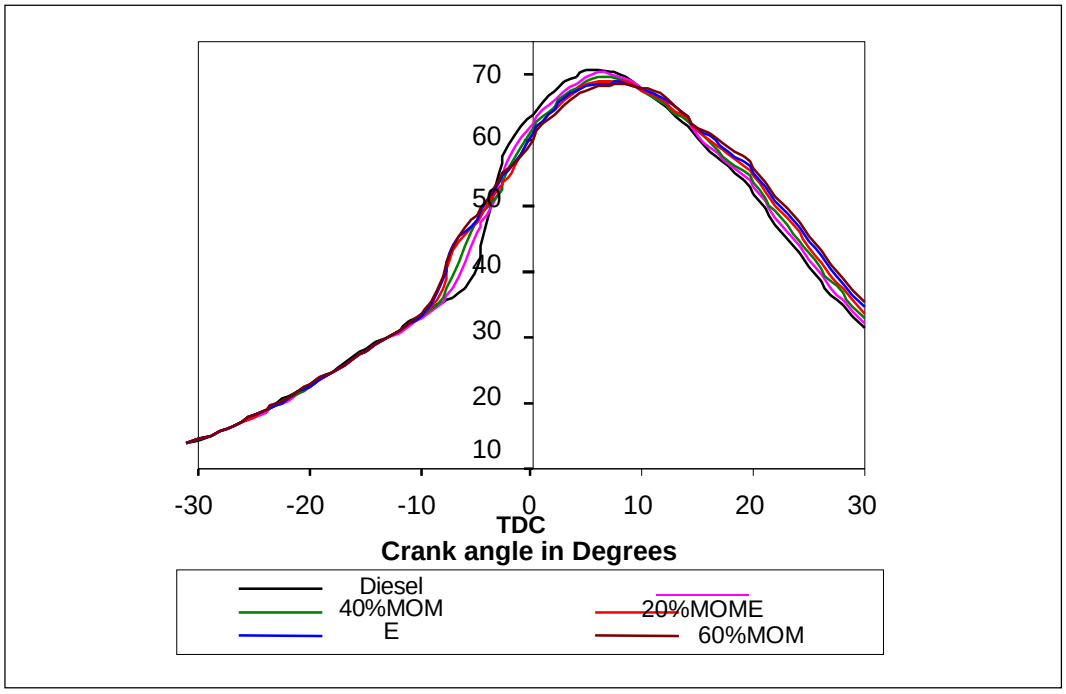

Fig.5.2: Pressure – crank angle diagram for MOME and its blends at rated load (4.4kW)

Peak pressure (p_{max})

From the literature review different trends are being observed by different researchers on the variation of peak pressure when methyl ester and its blends are used in diesel engines. The peak pressure is also found to increase with the percentage of methyl ester in few cases and decrease is noted in majority of cases (Suryawanshi et al, 2005).. As the percentage of the methyl ester in the blend increases, the peak pressure decreases. The decrease in peak pressure at rated power (4.4kW) is 0.83%, 1.34%, 2.330% 2.68% and 3.16 % for 20% MOME, 40% MOME, 60% MOME,80% MOME and MOME respectively compared to diesel. This is also due to the lower calorific value of the blends of methyl ester and poor atomization.

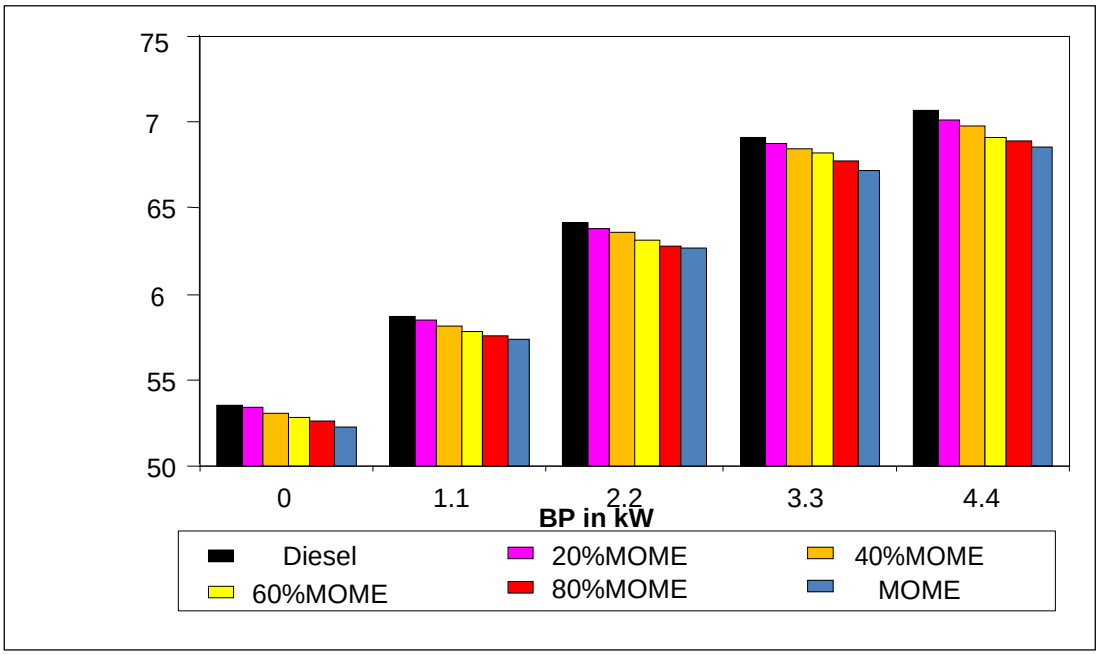

Fig.5.3: Comparison of peak pressure for MOME/diesel blends

3) Heat release rate (Q)

From figure 5.1 the ignition delay for 20%, 40%, 60%, 80%, 100% MOME and diesel, at rated power are 14.80, 14.520, 14.40, 13.980 and 13.630 respectively. It is being seen that the delay period at rated power for the blends of MOME decreases with increase in their percentage in the blend. Therefore the peak heat release rate decreases and occurs earlier for methyl ester and its blends as the percentage of methyl ester in the blend increases compared to diesel. FIG5.14, the peak heat release rates of diesel, 20% MOME, 40% MOME, 60%MOME, 80%MOME and MIME are 71.469 J/0CA, 68.21 J/0CA, 59.81 J/0CA, 56.51 J/0CA,52.948 J/0CA, and 51.482 J/0CA respectively and they occur at crank angles of 60, 60, 70, 70, 80 and 90 before TDC. It is also seen that the methyl ester and its blends show higher heat release rates than diesel in last phase seeing combustion due to the late burning of higher fatty acid components of methyl esters.

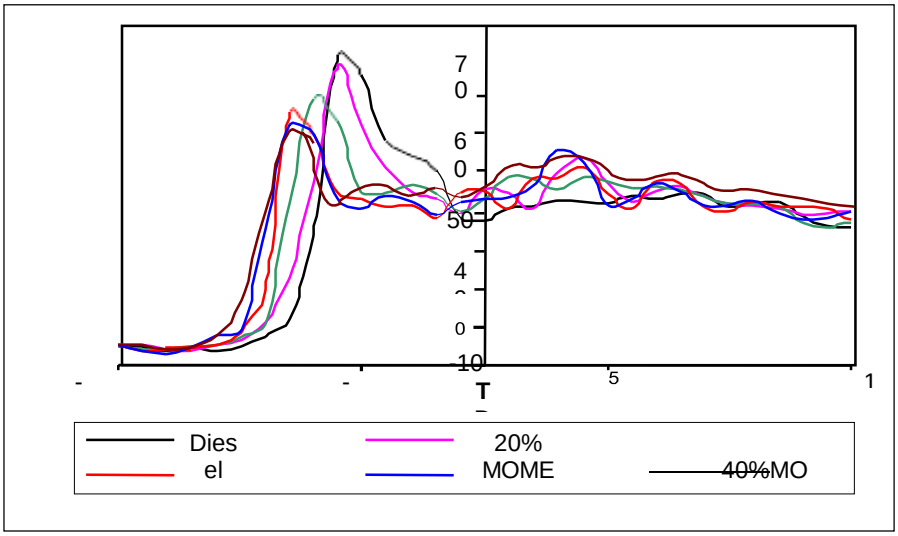

Fig.5.4: Comparison of rate of heat release for MOME/diesel blends at rated load (4.4kW)

B. PERFORMANCE AND EMISSION CHARACTERISTICS AT STANDARD INJECTION TIMING

Engine performance characteristics are being the major criteria that govern the suitability of a fuel. This study is related with the emerging of BTE (BTE) of the methyl ester-diesel blends.

The brake thermal efficiency variations of various test fuels at various brake powers are shown in Figure 5.5.. For instance, at rated power (4.4kW) the brake thermal efficiency of diesel, 20% MIME, 40% MIME, 60% MIME, 80% MIME and MIME are 33.35 %, 31.43 % (1.83 %), 30.55% (2.81%), 29.56% (3.82%), 28.65% (4.71%) and 27.61% (5.75%) respectively.

The Figure in bracket is showing the decrease in brake thermal efficiency of blends of MIME compared to diesel. The maximum decrease for various blends of MOME at rated power is only 5.75 % compared to diesel. Since the engine is operated under constant injection advance and methyl ester and its blends have smaller ignition delay.

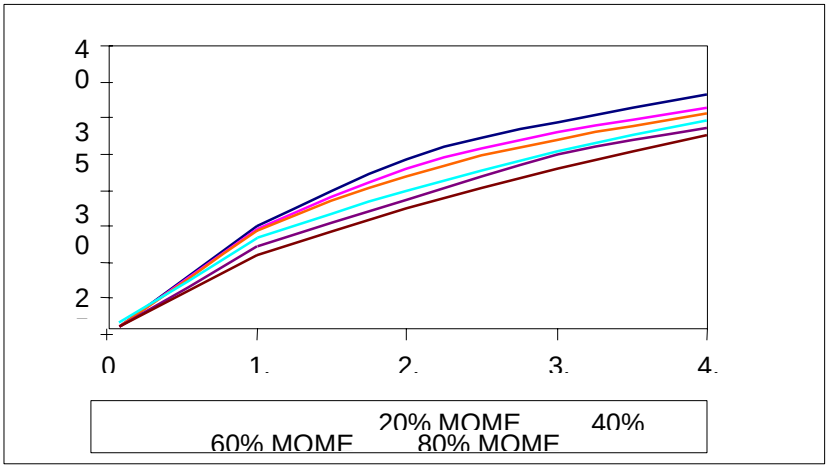

Fig.5.5: Comparison of brake thermal efficiency for MIME/diesel blends

1) Exhaust gas temperature (Teg)

Figure 5.6 show the exhaust gas temperature variations for methyl esters and its blends with brake power. It is observed that the exhaust gas temperature increases with brake power as more fuel is burnt at higher loads to meet the power requirement. It is also observed that the exhaust gas temperature increases with percentage of methyl ester in the fuel for all the loads. This may be due to the oxygen content of the methyl ester, which improves combustion. Also the poor fuel atomization and vaporization due to higher viscosity of the methyl esters and their blends results in late burning of injected fuel and higher exhaust gas temperature (Kerihuel et al, 2005).

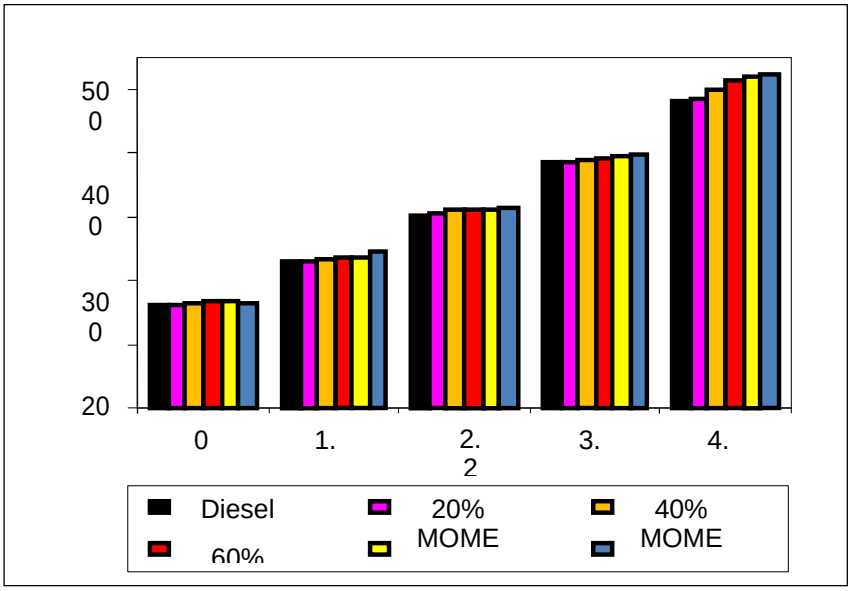

Fig.5.6: Comparison of exhaust gas temperature for MOME/ diesel blends

Table 5.2 Comparison of performance and emissions of methyl ester and its blends

Parameter	Injection Timing (bTDC)	Diesel	20% MOME
BTE	23.41º CA	33.36	31.52
	20.92º CA		30.89
	18.41º CA		29.96
UBHC	23.41º CA	48	38
	20.92º CA		41
	18.41º CA		43
CO	23.41º CA	0.25	0.24
	20.92º CA		0.23
	18.41º CA		0.27
PM	23.41º CA	140	132
	20.92º CA		144
	18.41º CA		150
NOx	23.41º CA	510	552
	20.92º CA		505
	18.41º CA		482

VI. CONCLUSIONS

In summary, the present work reports on the preparation of methyl ester from selected vegetable oil and predicted its combustion, performance and emission characteristics and describe the reduction of NOx techniques when used in diesel engine.

- The conclusions have been divided into three subdivisions as follows.
- Optimization of transesterification process.
- Methyl ester and its diesel blends as fuels for diesel engine.
- Effect of injection timing retardation on the performance and emissions.

A. OPTIMIZATION OF TRANSESTERIFICATION PROCESS

In this work, the preparation of methyl ester is optimized to get maximum yields by varying amounts of catalyst, alcohol and reaction temperature. It is found that the optimized parameters are 90% of stoichiometric amount of catalyst, 6:1 molar ratio of alcohol and 55oC reaction temperature to get maximum quantity of methyl esters from selected oil. The physical properties of prepared methyl ester satisfy the Indian standards for biodiesel.

B. METHYL ESTERS AS FUELS

From the investigation of the use of methyl ester and its diesel blends from mahua oil as alternative fuels for diesel engine, the following conclusions are derived:

Ignition delay period decreases with increase in percentage of methyl ester in the fuel. Methyl ester and its blends record slightly lower values of peak pressure compared to diesel. Peak pressure occurs slightly away from TDC for the methyl esters and their blends. The magnitude of maximum rate of heat release decreases with increase in percentage of methyl ester in the fuel. The occurrence of maximum rate of heat release advances with increase in percentage of methyl ester in the fuel.

Methyl ester and its diesel blends show slightly lower brake thermal efficiency compared to diesel. The unburned hydrocarbon, carbon monoxide and particulate matter in the exhaust decrease with increase in percentage of methyl ester in the fuel while exhaust gas temperature and nitrogen oxide emissions increase.

C. EFFECT OF INJECTION TIMING

The effects of retardation of injection timing on combustion, performance and emission parameters of 20% blend of methyl ester and diesel fuel can be summarized as follows:

- Start of combustion and occurrence of maximum rate of heat release retard with retardation of injection timing. The magnitude of peak pressure and maximum rate of heat release decrease with increase in retardation of injection timing.
- The brake thermal efficiency is found to decrease when the injection timing is retarded and reduces with increase in retardation of injection timing.
- The nitrogen oxide emissions reduce with increase in retardation of injection timing but other components of emissions like unburned hydrocarbon, carbon monoxide and soot concentration increase.
- Hence it is recommended to use injection timing of 20.9oCA bTDC for 20%blend of MIME from the emissions and economy point of view.

D. SCOPE FOR FUTURE WORK

The results of this investigation based on short tests of each fuel. The investigation will be completed only if tests are carried out on the carbon deposits on various engine components like engine valves, piston, cylinder etc.

Further a novel fuel additive, PuriNOx (TM), developed by Lubrizol Corporation unlike conventional fuel additives that reduce combustion efficiency and performance, this new chemical will lower the flame temperature to reduce NOx and particulate matter production, with no penalty to efficiency or performance can be tested for this diesel engines.The engine can be tested for its performance and emission analysis by making minor changes with the combustion chamber, with multi point fuel injection systems, yet increasing fuel injection pressures taking needed precautions, stratified fuel supply etc.

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