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IMPACT OF OPERATING PARAMETER AND EFFECT OF WORKING CHARACTERISTICS OF VCR ENGINE

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ABSTRACT:
The experimental investigation aims to utilize the bio energy in a four stroke, single cylinder, water cooled and compression ignition engine with three compression ratios 17:1, 17.5:1 and 18:1 was used for the experiment. Also the blend ratios are M10, M20and M30 biodiesel blendswere used for conducting the experiment at varying load conditions with a constant speed 1500rpm. The important properties of mahua methyl ester blends were compared with diesel fuel.The characteristics such as fuel consumption and emissions (HC, CO, CO_2, smoke) were superior at compression ratio 18:1and the blend B20, but considering the engine vibration and noise of the CR is limited to a value of 18:1.
Keywords: Mahua Oil Methyl Ester,Performance, Combustion and Emission,Variable Compression Ratio (VCR), diesel engine, Biodiesel.

INTRODUCTION:

The performance, emission and combustion of DI diesel engine using rapeseed oil and its blends of 5%, 20%, 70% and standard fuel. It has been observed that the biodiesel produces lower smoke emission and higher brake specific fuel consumption compare to the diesel fuel [1].
It has been concluded that alkali catalyst process given high conversion levels oils to methyl esters. The effect of biodiesel types, biodiesel fraction and physical properties on combustion and performance characteristics of a CI engine. They have conducted experiments in multi cylinder, DI and turbo charged diesel engine using biodiesel blends of waste cooking oil, rapeseed oil and corn oil with normal diesel. It has been seen that the bio diesel types didn't haveany significant differences in peak cylinder pressure and BSFC [2-3]. The biodiesel produced from Mahua (Madhuca Indica) oil through transesterification process. The results show that 4% H_2SO_4, 0.33% v/v alcohol/oil ratio, 1 hr reaction time and 65^o C temperature are the optimum conditions for esterification. The kinetic viscosity and cetane value were higher for mahua oil and thus will be favorable for combustion. The suitability of transesterified mahua oil is best suit in C.I. engine. The experiments 7 HP single cylinder four stroke and vertical, water cooled Kirloskar diesel engine at rated speed of 1500rpm.The increase in brake thermal efficiency and decrease in specific fuel consumption was observed in the case of esterified mahua oil (at 75% mahua oil blends) compared to that of diesel fuel. The emissions of CO, HC were too low for mahua oil methyl ester and Oxides of nitrogen were slightly higher compared with diesel. The combustion analysis of CI engine using Mahua biodiesel shows a lower ignition delay when compared to the diesel and the heat release rate was more during diffusion combustion of biodiesel and its blends. [4-9].Themechanism of a dual process adopted for the production of biodiesel from Karanja oil containing FFA up to 20%. The conventional alkali-catalyzed route of biodiesel production does not work out effectively with high FFA feedstock such as Karanja oil. However, the dual-step process of transesterification using acid-catalyzed and followed by base-catalyzed reaction proves effective in producing the appropriate quality of biodiesel as per the ASTM specification [10]. The production of biodiesel fromKaranja oil (pongamia pinnata), and the effect of biodiesel in engine performance and emission was studied. They have conducted experiment in a single cylinder water cooled, naturally aspired, 4-stroke DI

diesel engine. They have found that B100 reduced CO and smoke emissions by 50% and 45% respectively, while 15% increase in the NO_x emissions was observed with the same fuel [11].The performance and emission of a diesel engine fueled with pongamia pinnata methyl ester (PPME) and its blends with the diesel fuel. The blends of PPME of to 40% (B40) could replace the diesel for diesel engine because of their low emissions and better performance [12].The effect of performance and emission characteristics of a single cylinder, naturally aspired, four strokes, DI diesel engine fueled with cottonseed oil and its blends. The exhaust emissions including CO, PM and smoke emissions were reduced for all biodiesel mixture with slight increase in NOx was emission [13]. The experiments on single cylinder DI air cooled diesel engine using the performance and emissions of cotton seed oil methyl ester (CSOME) in a diesel engine. The CSOME was added to diesel fuel, by volume of 5% (B5), 20% (B20) 50% (B50) and 75% (B75) as well as pure CSOME (B100).The CO emission and NOx emissions were considerably decreased for all blends [14]. They have carried out experiments on single cylinder 4 stroke variable compression ratio engine using biodiesel with producer gas with different compression ratio. They have reported that the brake thermal efficiency increases with the increase in compression ratio (CR) with simultaneous reduction in brake specific fuel consumption. They have also reported that emission reduction ensures the suitability of mixed fuel at higher compression ratio without any modification in the engine. They have concluded that ignition delay, noise pollution and engine vibration with limit the CR to 18.Theexperiments on single cylinder four stroke variable compression ratio (VCR) engine with waste cooling oil methyl ester and its blends with diesel. They have reported that the BTE for B40 and compared with diesel fuel. They have also reported that NOx emission increases with biodiesel blend expect B40 blend. [15-16].

EXPERIMENTALMATERIAL SAND METHODS:

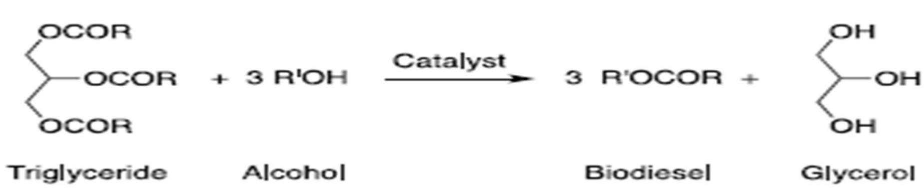
Mahua, Madhuca long folia of the family Sapotaceae, is a medium to large tree with a wide round canopy. Mahua is a slow-growing species, attaining a mean height of 0.9– 1.2 m at the end of the fourth year but may attain a height of up to 20 m. The variety latifolia is common throughout the Indian sub-continent, including Bangladesh. It is of deciduous nature and thrives in dry tropical and sub-tropical climates. As a plantation tree, mahua is an important plant having vital socio-economic value. This species can be planted along the roadside and canal banks on a commercial scale and in social forestry programs, particularly in tribal areas. The seed kernel contains about 50% oil. The oil yield by screw pressing is 34–37% and the fresh oil from properly stored seed is yellow in colour [17].

Transesterification :

Transesterification is the process of using an alcohol (e.g. methanol or ethanol) in the presence of catalyst such as sodium hydroxide (NaOH) or potassium hydroxide (KOH), which chemically breaks the molecule of the raw oil into methyl or ethyl esters with glycerol as a by-product, which reduces the high viscosity of oils. This method also reduces the molecular weight of the oil to 1/3 of its original value, reduces the viscosity and increase the volatility and cetane number to levels comparable to diesel fuel. Conversion not greatly affects the gross heat of combustion.

PROPERTIES OF MAHUA METHYL ESTER:

Mahua methyl ester properties were tested according to American standardTesting methods (ASTM) the moisture content ofMahua biodiesel is 0.05%. The properties included kinematic viscosity, cetane number, flash point, fire point and heating value was determined



with the following specific standard procedures. The propertiesMahua methyl ester and neat diesel are shown in Table 1.

Table 1. Properties of Mahua Methyl Ester

PROPERTY	Diesel	MOME	M10	M20	M30
Kinematic viscosity in cst at 40^0 C	3.1	5.2	3.6	4.2	4.7
Calorific value in Kj/kg	43200	36900	37500	38100	38800
Density at 15^0C in kg/mm^3	830	890	840	840	850
Cetane no.	46.4	52	47	48	48.5
Flash point (^{0}C)	56	91	61	64	67
Fire point (^{0}C)	64	104	70	73	78

EXPERIMENTAL SETUP:

Load test was conducted to evaluate the performance, combustion and emission characteristics in a single cylinder, four stroke, water cooled, DI diesel engine using three blends of Mahua methyl ester (M10, M20, M30) as a fuel. An eddy current dynamometer is connected with this engine as a loading device at constant engine speed. AVL 5-gas analyzer and AVL 437 Smoke meter are used to determine the emission characteristics of the engine. Pressure during combustion was measured using piezo electric pressure transducer and was connected to the data acquisition system connected to the PC. The appropriate heat release rate will be calculated using the software. Figure 1 shows the schematic view of the experimental setup.

SPECIFICATIONS OF THE APPARATUS:

In the test rig there are several instruments/equipment have been used for the purpose of the experiment. Brief specification, the calibration procedure and working principle of all the instruments used for conducting the experiment are given below.

DIESEL ENGINE

Manufacturer	:	Kirloskar oil engines limited
Type of Engine	:	Vertical, 4-Stroke Single cylinder
Model	:	SV1
Rated Output	:	3.5kW
Speed	:	1500 rpm
Compression Ratio	:	17.5:1
Bore and stroke	:	87.5 x 110 (mm)

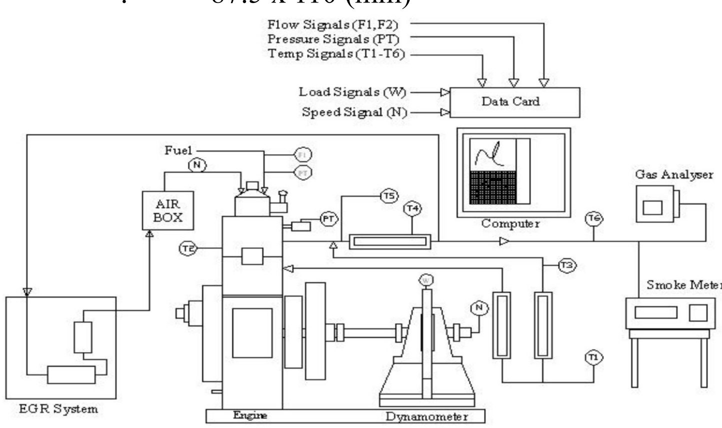


Figure 1 Schematic diagram of Experimental set up

SMOKE METER:

Smoke meter is used to determine the smoke density of the engine exhaust. The AVL 437 Smoke meter has been designed for simple one man operation either from alongside a vehicle for either free acceleration or steady state test procedure. Control is via a compact and rugged handset with a digital L.C.D. display. Any out of range parameters are automatically flagged to the operator. The brief specifications of the smoke meter are given below.

Type	:	AVL 437 Smoke meter
Make	:	AVL India Pvt. Ltd.
Measuring range	:	0 to 100 HSU

EXHAUST GAS ANALYZER :

A gas analyzer is used to measure the exhaust gas composition. The brief specification of exhaust gas analyzer is given below.

- Manufacturer : AVL
- Type : AVL 5- gas analyzer
- Ranges : CO - 0 to 10 %
  CO_2 - 0 to 20 %
  HC - 0 to 10000 PPM
  O_2 - 0 to 25
  NO_X - 0 to 5000 PPM

TESTING PROCEDURE:

Engine was started and warmed up at low idle, long enough to establish the recommended oil pressure, and was checked for any fuel, oil leaks. The engine was run on no-load condition and speed was adjusted to 1500 rpm by adjusting fuel injection pump. Engine was run to gain uniform speed, after which it was gradually loaded. Experiments were conducted at different load levels. The engine was run for 10 minutes and data were collected during last 4 minutes.The exhaust gas is sampled from exhaust pipe line and passed through an exhaust gas analyzer for measurement of carbon monoxide, carbon dioxide, unburnt hydrocarbon, oxides of nitrogen present in exhaust gases. A smoke meter is used for measurement of smoke capacity. Three sets of readings were taken during each load condition to minimize the error

5. Results and Discussion- Performance, Emission and Combustion Characteristics of Biodiesel Blend by

BRAKE SPECIFIC FUEL CONSUMPTION (BSFC):

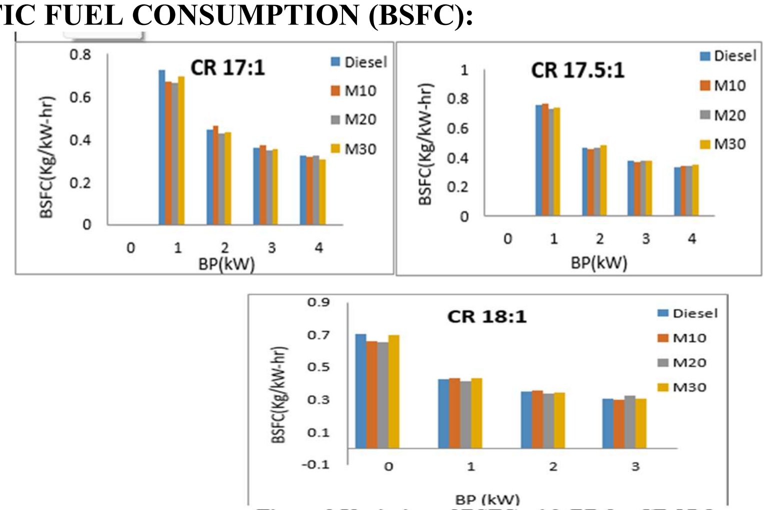


Figure 2.Variation of BSFC with BP for CR 17:1, 17.5:1and 18:1

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Fig. 2 shows the variation of BSFC for different blends of MOME and neat diesel fuel for different compression ratios. It is observed that the BSFC gradually decreases with increasing compression ratio. At maximum load with the compression ratio of 18:1, the BSFC for M10 is 0.301kg/kW-hr and 3% reduction of BSFC is observed when compared with the neat diesel fuel. This is due to increase in compression ratio leads higher temperature during end of compression which leads better combustionand also oxygen present in the biodiesel enhance the combustion.The resultsshows better BTE and lower BSFC. Further, it is also due to low compared to diesel which higher volatility and higher cetane number of biodiesel which will result in improved combustion at higher compression ratio. According to blend ratio, the BSFC for M10 is lower than that of other blends under high compression ratio and full load conditions. At high percentage of blends, the BSFC increases due to fuel density, viscosity and heating value of the biodiesel. However increase in BSFC is observed with lower compression ratio because of slow combustion process.

Brake thermal efficiency (BTE)

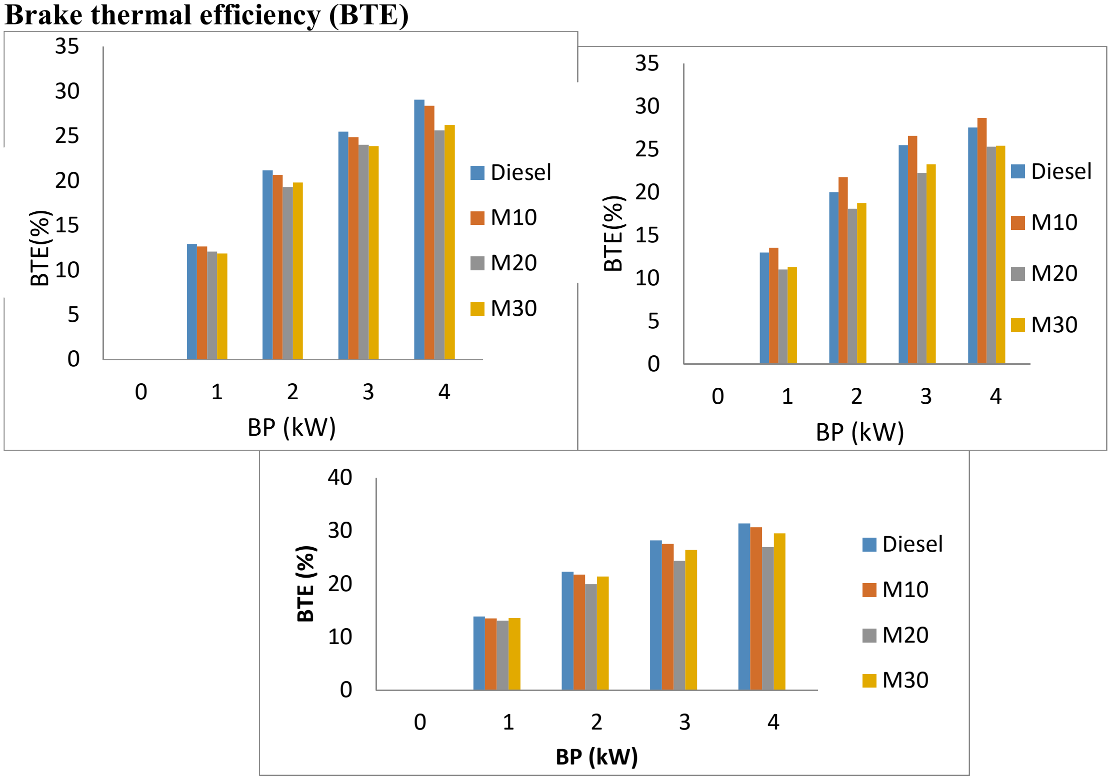

Figure.3. Variation of BTE with BP for CR 17:1, 17.5:1and 18:1

Fig 3 shows the variation of BTE for different blends of MME and neat diesel fuel with different compression ratios. It is observed that the BTE gradually increase with increasing compression ratio. At maximum load with the compression ratio of 18, the BTE for M10 is 30.67% and it is almost equal to the neat diesel fuel (31.47%). This is due to increase in compression ratio ensures better air-fuel mixing and faster evaporation and leads to complete combustion. Further, it is also due to biodiesel blends had low volatility when compared to diesel fuel and therefore the improvement in their combustion characteristics at high temperature resulted from high compression ratio than the improvement in case of diesel fuel with the same compression ratio rise. According to blend ratio, the BTE is reduced with the increasing concentrations of biodiesel in the blend at all compression ratios. The BTE for M10 is higher than that of other blends under higher compression ratio and full load conditions. This is due to presence of excess amount of oxygen in M10 which resulted in improved combustion when compared to the neat diesel fuel.

Exhaust Gas Temperature (EGT):

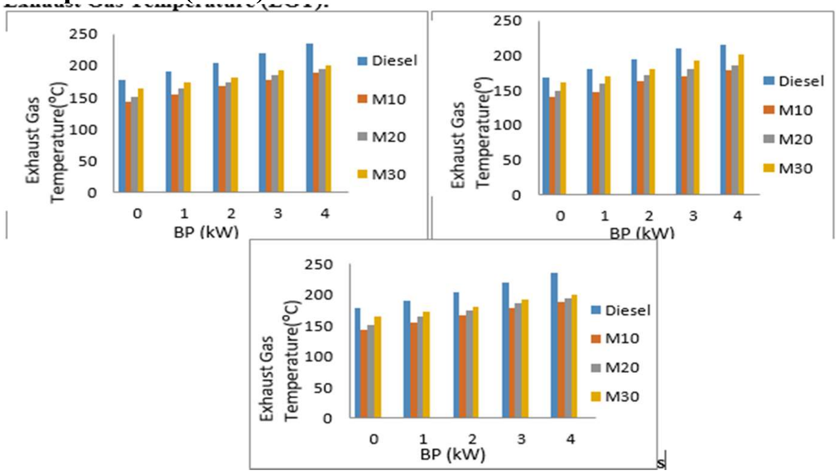

Figure 4. Variation of EGT with BP for CR 17:1, 17.5:1and 18:1

Fig 4 shows the variation of EGT for different blends of MME and neat diesel fuel with different compression ratios. It is observed that the EGT gradually decreases with increasing compression ratio. At maximum load with the compression ratio of 18, the EGT for M10 is 189^{o} C and 19.6% reduction in EGT is observed when compared with the neat diesel fuel. This is due to shifting of the combustion process slightly to the earlier stroke of the cycle at high compression ratio. Hence, more of the fuel energy is utilized effectively for developing brake power and leads to reduction in exhaust gas temperature. According to blend ratio, the EGT increases with the increasing concentrations of biodiesel in the blend at all compression ratios. The EGT for M10 is lower than that of other blends under higher compression ratio and full load conditions. This is due to the lower calorific value of blended fuel when compared to the neat diesel fuel and lesser temperature at the end of compression. Further, lower exhaust loss may be one of the possible reasons for higher performance.

CARBON MONOXIDE (CO) :

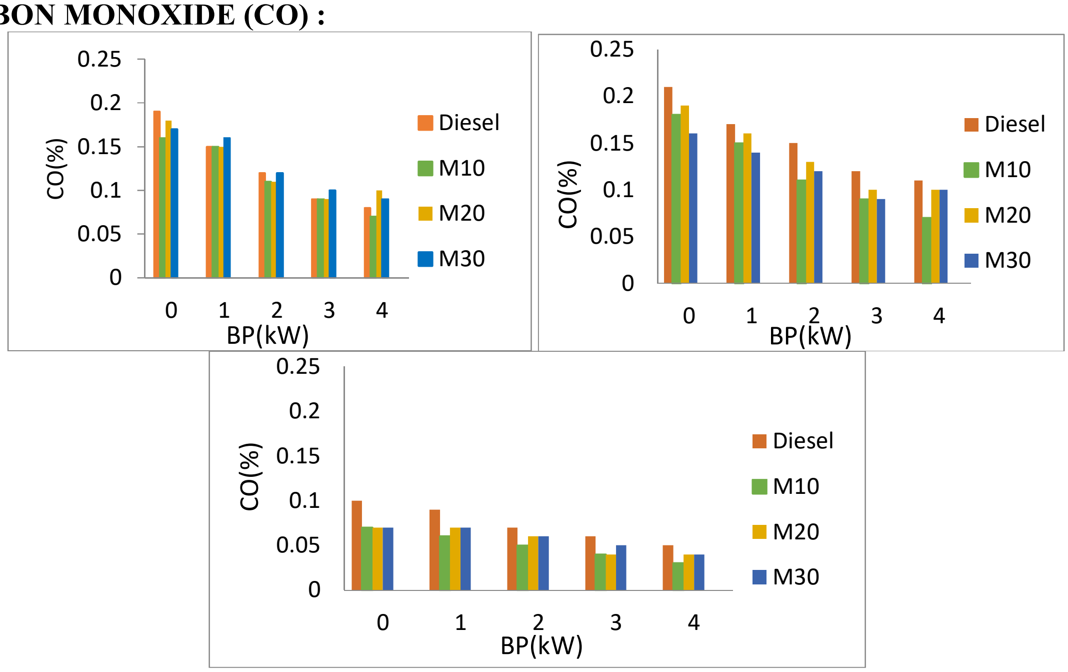

Figure 5. BP with CO for CR 17:1, 17.5:1and 18:1

Industrial Engineering Journal
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Volume : 54, Issue 6, No.3, June : 2025

Fig 5 shows the variation of CO for different blends of MME and neat diesel fuel with different compression ratios. It is observed that the CO gradually decreases with increasing compression ratio. At maximum load with the compression ratio of 18, the CO for M10 is 0.03 % and 40% reduction of CO is achieved when compared with the neat diesel fuel. This is due to complete combustion; less dilution of charge by residual gases accelerates the carbon oxidation to form carbon dioxide. Further, it is also due to increase in compression ratio actually increase the air temperature inside the cylinder consequently reduction in delay period cause better and complete burning of the fuel and lower the CO emissions. According to blend ratio, the CO emission increases with the increasing concentrations of biodiesel in the blend at all compression ratios. The CO emission for M10 is lower than that of other blends under higher compression ratio and full load conditions. This is due to presence of additional oxygen content in the biodiesel, which enhances the complete combustion and leads to reduction in CO emission.

HYDROCARBON (HC) :

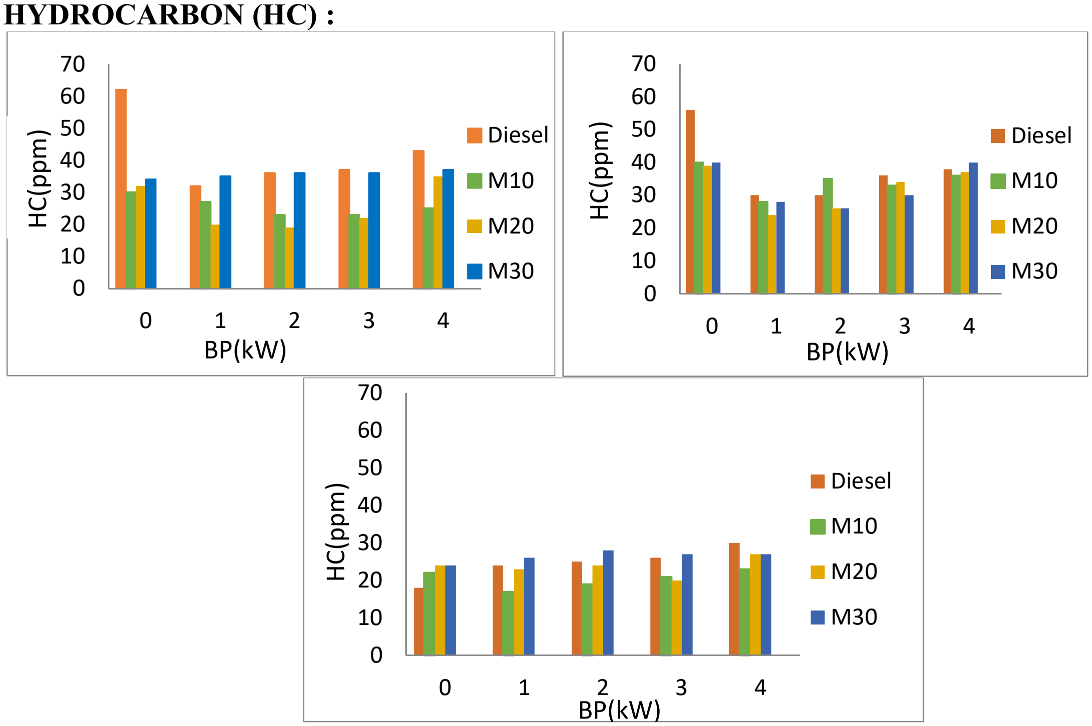

Figure.6. BP with HC for CR 17:1, 17.5:1and 18:1

Fig 6 shows the variation of HC for different blends of AME and conventional diesel fuel with different compression ratios. It is observed that the HC gradually decreases with increasing compression ratio. At maximum load with the compression ratio of 18, the HC for M10 is 23ppm and 23.33% reduction of HC is achieved when compared with the neat diesel fuel. This is due to increase the air temperature at the end of compression stroke, enhancement in combustion temperature and reduction in charge dilution leads to complete combustion and reduction in hydrocarbon emissions. This is also because of better combustion of biodiesel inside the combustion chamber due to the availability of oxygen in biodiesel when compared to neat diesel fuel. According to blend ratio, the HC emission increases with the increasing concentrations of biodiesel in the blend at all compression ratios. The HC emission for M10 is lower than that of other blends under higher compression ratio and full load conditions. This is due to longer ignition delay and accumulation of fuel in the combustion chamber may cause higher HC emission. Further it is also found that Increase in hydrocarbon emission is observed with reduction in compression ratio is due to slow combustion process.

Smoke :

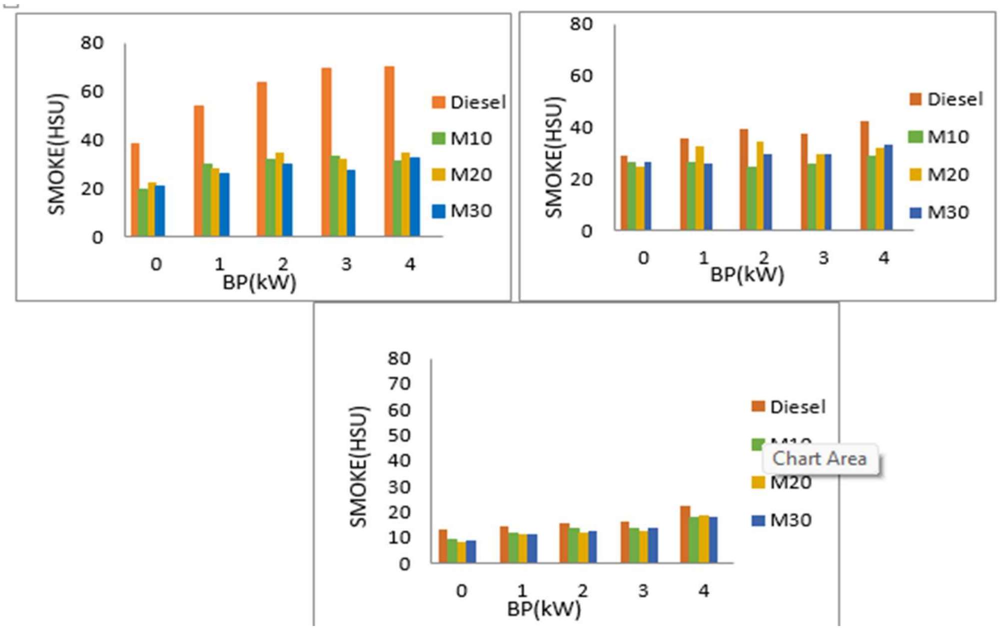

Figure 7. BP with Smoke for CR 17:1, 17.5:1and 18:1

Fig 7 shows the variation of Smoke for different blends of MME and conventional diesel fuel with different compression ratios. It is observed that the Smoke gradually decreases with increasing compression ratio. At maximum load with the compression ratio of 18, the smoke for M10 is 17.6HSU and 21.4% reduction of smoke is achieved when compared with the neat diesel fuel. This may be due to biodiesel consists of two oxygen atoms which lead to the oxidation of soot and thereby reducing the soot emission. Further, it is also due to better oxidation environment and existence of higher temperature and pressure at higher compression ratio. Also it is reconfirmed the HC and CO emissions curve.

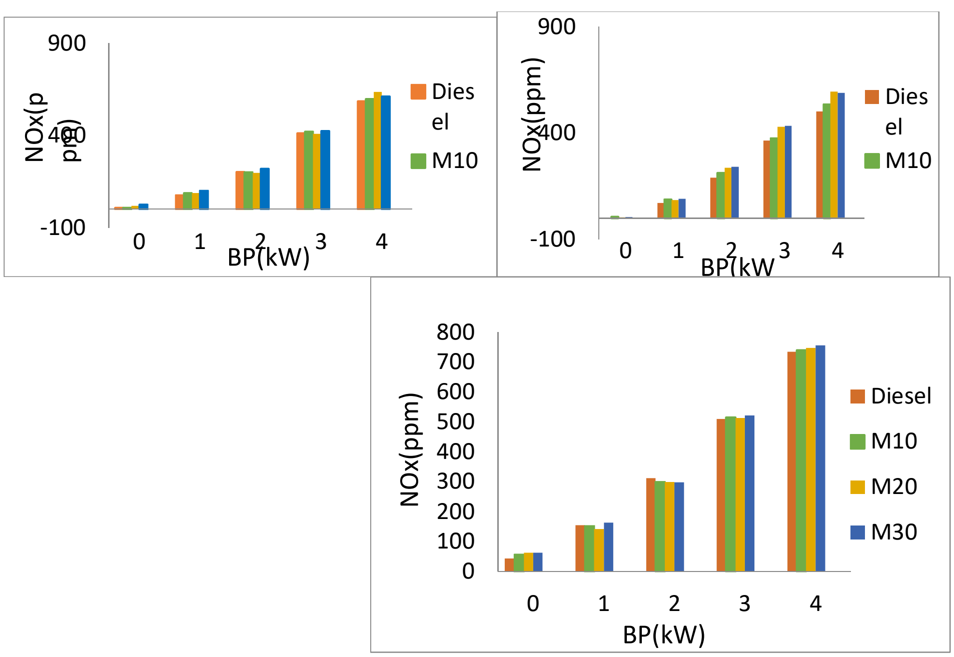

Figure 8. BP with NOx for CR 17:1, 17.5:1and 18:1

Fig 8 shows the variation of NO_x for different blends of MME and conventional diesel fuel with different compression ratios. It is observed that the NO_x gradually increase with increasing compression ratio. At maximum load with the compression ratio of 18, the NO_x for M10 is 740ppm and it is almost equal to the neat diesel fuel 734ppm.This is due to increase in compression ratio increases the combustion pressure and temperature which accelerates the oxidation of nitrogen to form oxides of nitrogen. Further it is also due to increase in compression ratio increase the combustion temperature which in turn increase the compression ration which leads to increase in NO_x emission. At high compression ratio, ignition delay reduces and peak pressure increases resulting in high combustion temperature and leads in increase in NO_x emission. According to blend ratio, the NO_x emission increases with the increasing concentrations of biodiesel in the blend at all compression ratios. The NO_x emission for M10 is lower than that of other blends under higher compression ratio and full load conditions.

CYLINDER PRESSURE :

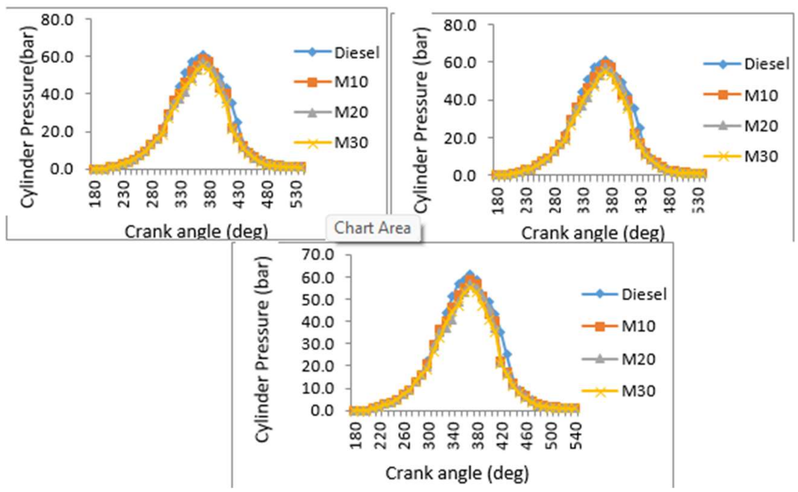

Figure 9Cylinder pressure with Crank angle CR 17:1, 17.5:1and 18:1

Figure 9 shows the variation of in-cylinder pressure with crank angle. The experimental results show that the Peak pressure decreases when compression ratio is retarded and increases when compression ratio is advanced. The maximum peak pressure is observed at three fourth of load for all fuels. The Peak pressure at three fourth of load increases by 2.22% for M10 blend at 17.5:1, 4.4% for M10 blend at 17:1, 5.2% for M10 blend at 18:1 .For M10 blend at 18:1, at three fourth of load the Peak pressure is found to be 10.2% lower when compared to diesel at three fourth of load at standard engine specification.

HEAT RELEASE RATE (HRR):

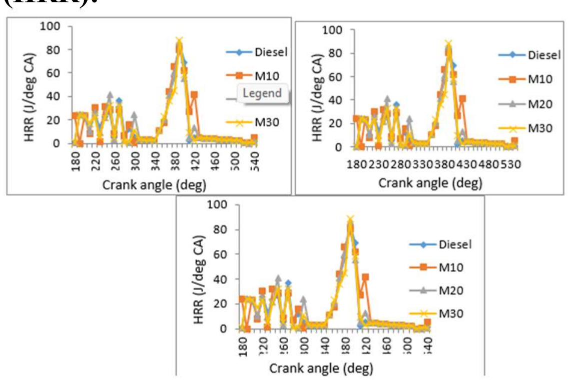

Figure 10Heat release rate (HRR) with Crank angle CR 17:1, 17.5:1and 18:1

Figure 10 shows the variation of HRR with crank angle. The experimental results show that the Heat release rate increases when compression ratio is retarded and decreases when compression ratio is advanced. The lower Heat release rate is observed at three fourth of load for all fuels. The Heat release rate at three fourth of load decreases by 4.6% for M10 blend at 17.5:1, 2.2% for M10 blend at 17:1, 1.2% for M10 blend at 18:1.For M10 blend at 18:1, at three fourth of load the Heat release rate is found to be 3.4% higher when compared to diesel at three fourth of load at standard engine specification.

CUMULATIVE HEAT RELEASE RATE (CHRR) :

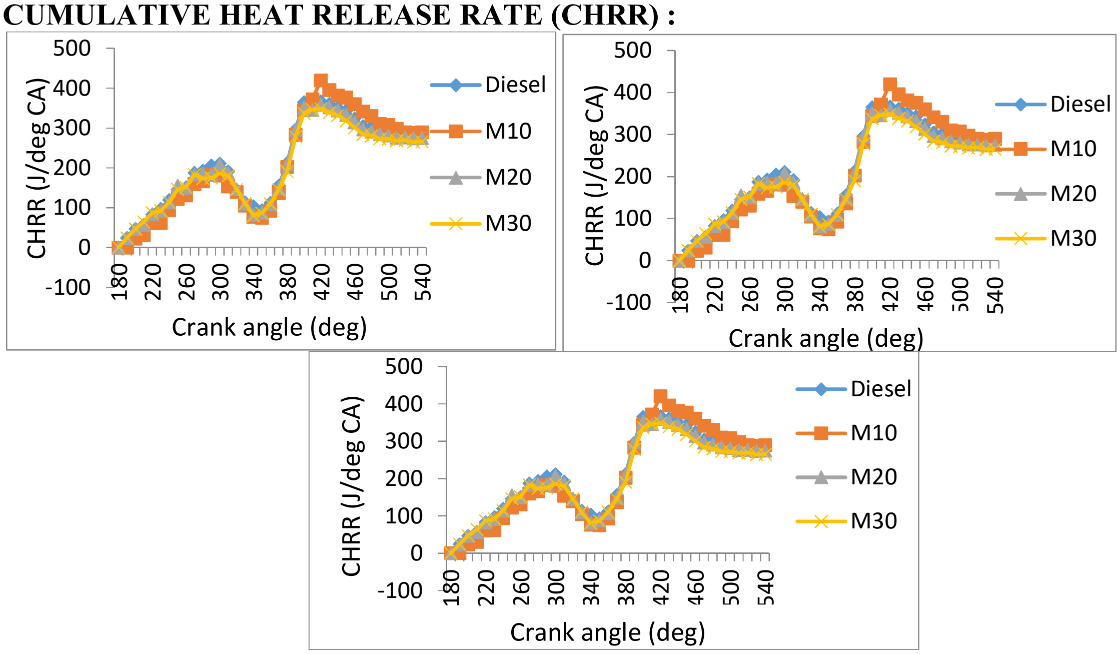

Figure 11Cumulative heat release rate (CHRR)VsCrank angle CR 17:1, 17.5:1 and 18:1

Figure 11 shows the variation of CHRR with crank angle. The experimental results show that the Cumulative heat release rate increases when compression ratio is retarded and decreases when compression ratio is advanced. The lower Cumulative heat release rate is observed at three fourth of load for all fuels. The Cumulative heat release rate at three fourth of load decreases by 17.7% for M10 blend at 17.5:1, 24.7% for M10 blend at 17:1 and 27.7% for M10 blend at 18:1.For M10 blend at 18:1, at three fourth of load the Cumulative heat release rate is found to be 7.3% higher when compared to diesel at three fourth of load at standard engine specification.

CONCLUSIONS

The fuel properties of mahua biodiesel were within limits except calorific value; all other fuel properties of mahua biodiesel were found to be higher as compared to diesel.

The brake specific fuel consumption is increased in decreasing load and increasing compression ratio. At maximum load with the compression ratio of 18:1, the BTE for M10 is 30.67% and it is almost equal to the neat diesel fuel (31.47%). This is due to increase in compression ratio ensures better air-fuel mixing and faster evaporation and leads to complete combustion. Further, it is also due to biodiesel blends had low volatility when compared to diesel fuel and therefore the improvement in their combustion characteristics at high temperature resulted from high compression ratio than the improvement in case of diesel fuel with the same compression ratio .

The heat release rate and cumulative heat release rate is slightly higher than diesel in B10 blend in all three compression ratios.

The experimental work was performed in single cylinder VCR engine at compression ratios 17:1, 17.5:1 and 18:1.the performance, emission and combustion characteristics of diesel were observed at various loads. Then the experimental investigation is made to examine the characteristics of the engine by using mahua bio-diesel as fuel.

The characteristics of the made blends are superior to the diesel fuel in all three compression ratios. The bio-diesel possesses certain characteristics superior at a specific ratio, and some characteristics at another compression ratio. But all those characteristics were superior to diesel. The characteristics such as fuel consumption and emissions (HC, CO, CO_2, smoke) were superior at compression ratio 18:1and the blend B20.

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