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Performance, Combustion and Emission Characteristics of Mahua Methyl Esters and It Blends In DI Diesel Engine

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***Abstract-* An experimental study was conducted to evaluate the performance, emission and combustion characteristics of Variable Compression Ratio (VCR) diesel engine with mahua oil methyl ester (MOME) as blended fuel with diesel. A four stroke, single cylinder, water cooled and compression ratio of 17:1, 17.5:1 and 18:1 was used for the experiment. Also the blend ratios are M10, M20 and M30 biodiesel blend was used for conducting the performance, emissions and combustion tests at varying load conditions with a constant speed 1500rpm. Various parameters such as brake thermal efficiency(BTE), brake specific fuel consumption(BSFC), exhaust gas temperature(EGT) and emissions of carbon monoxide (CO), hydrocarbon (HC), smoke and oxides of nitrogen gases (NOx) in exhaust and combustion parameters such as cylinder pressure, heat release rate (HRR), cumulative heat release rate (CHRR) is evaluated. The test results indicates that M10 blend with CR 18:1 shows better performance and lower emissions, but considering the engine vibration and noise of the CR is limited to a value of 18:1.**

***Index Terms-* Mahua Oil Methyl Ester, Performance, Emission and Combustion, Variable Compression Ratio (VCR) diesel engine**

1. 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 observed that the biodiesel produces lower smoke emission and higher brake specific fuel consumption compare to the diesel fuel. It has been concluded that alkali catalyst process given high conversion levels oils to methyl esters. 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 have any significant differences in peak cylinder pressure and BSFC [2-3]. The combustion analysis of CI engine using biodiesel shows a lower ignition delay when compared to the diesel and the heat release rate was more during diffusion combustion of biodiesel and their blends. The bio diesel production from Mahua (Madhuca Indica) oil through esterification followed by transesterification. The results show that 4% H_2SO_4, 0.33% v/v alcohol/oil ratio, 1 hr reaction time and 65o 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 effect mahua oil methyl ester, ethyl and butyl esters of a four stroke, direct injection, constant speed, compression ignition diesel engine, on performance and emissions .The CO, HC and NOx is low for alkali esters compared to diesel. The ethyl ester showed lower NOx emission compared to other esters. The mahua oil methyl ester was in a single cylinder, four stroke, direct injection, constant speed, compression ignition diesel engine on the performance and emissions. The emissions of CO, HC were too low for mahua oil methyl ester and Oxides of nitrogen were slightly lower compared with diesel. The experiment on a single cylinder, four stroke compression ignition engine using Mahua oil methyl ester and diesel as fuel. The thermal efficiency is found to be at par with diesel and is a significant drop in specific emissions of such as hydrocarbon, carbon monoxide and smoke emissions [4-9]. The mechanism 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].

2. EXPERIMENTS

2.1 Material 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].

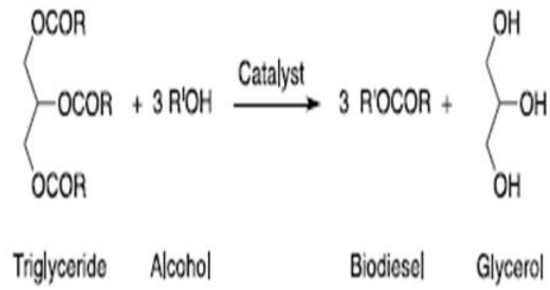
2.2. Extraction

2.2.1 Mechanical Expeller (production scale):

Seeds are crushed using mechanical expeller to get oil. (Mechanical expeller is of capacity 30 kg/hr, 3 passes). For a batch 5 kg of seeds are taken to crush, each batch of seeds passed 5times to obtain complete oil. Oil obtained was collected in a glass reagent container by filtering it with filters. Filtered oil left for 10-12 hrs for settling of minute dust particles. After filter and settling, oil stored in a reagent glass bottle.

2.3. 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.

3. PROPERTIES OF MAHUA METHYL ESTER

Mahua methyl ester properties were tested according to United States standard methods (ASTM) the moisture content of Mahua 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 properties Mahua methyl ester and neat diesel are shown in Table 1.

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

Table 1. Properties of Mahua Methyl Ester

4. 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. The schematic diagram (fig. 1) shows the experimental setup.

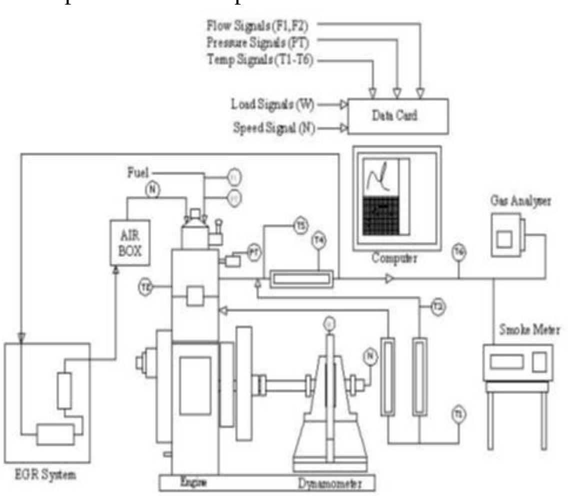


Figure 1 Schematic diagram of Experimental set up

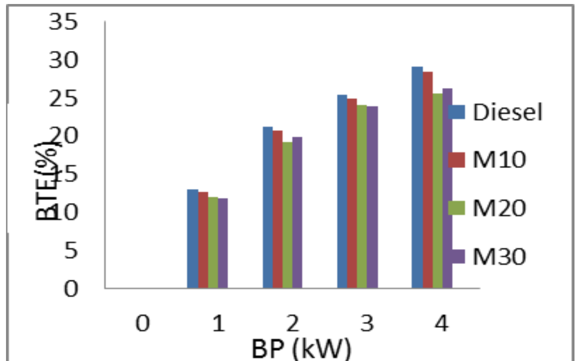
4.2. Testing Procedure

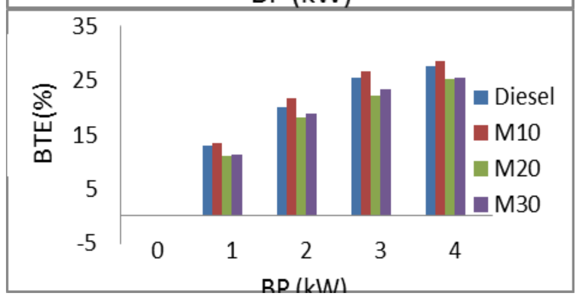
Engine was started and warmed up at low idle, long enough to establish the recommended oil pressure, and was checked for any fuel, oil leaks. The engine was run on no-load condition and speed was adjusted to 1500 rpm by adjusting fuel injection pump. Engine was run to gain uniform speed, after which 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, un burnt 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

5.1. Performance, Emission and Combustion Characteristics of Biodiesel Blend by Varying Compression Ratios

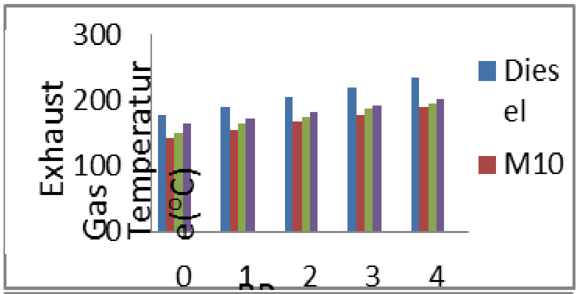
5.1.2 Brake thermal efficiency (BTE)

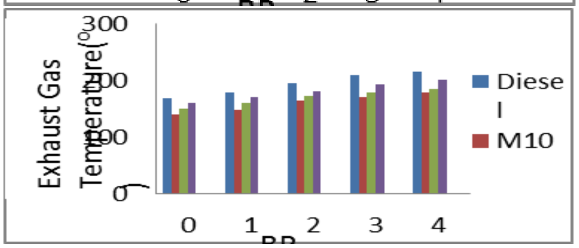




The variation of BTE for different blends of MME and neat diesel fuel with different compression ratios. It is observed that the BTE gradually increase with increasing compression ratio. At maximum load with the compression ratio of 18, the BTE for M10 is 30.67% and it is almost equal to the neat diesel 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.

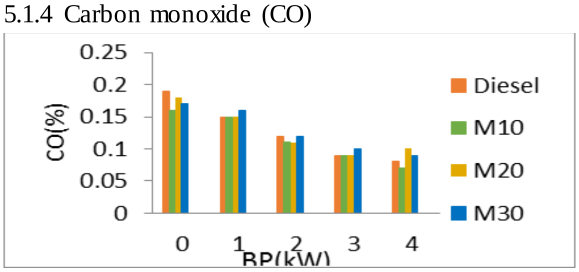
5.1.3 Exhaust Gas Temperature (EGT)

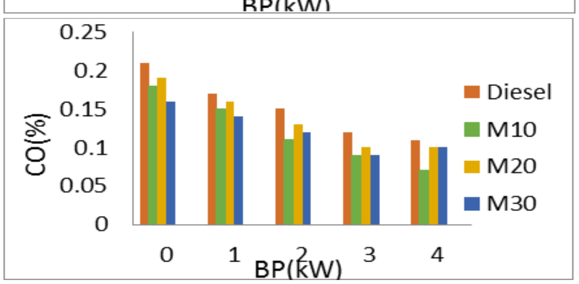




The variation of EGT for different blends of MME and neat diesel fuel with different compression ratios. It is observed that the EGT gradually decreases with increasing compression ratio. At maximum load with the compression ratio of 18, the EGT for M10 is 189 o C and 19.6% reduction in EGT is observed 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.

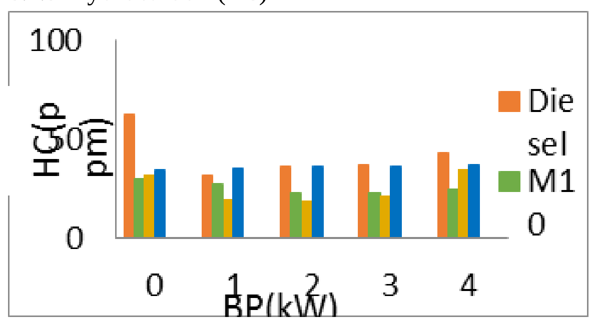
5.1.4 Carbon monoxide (CO)

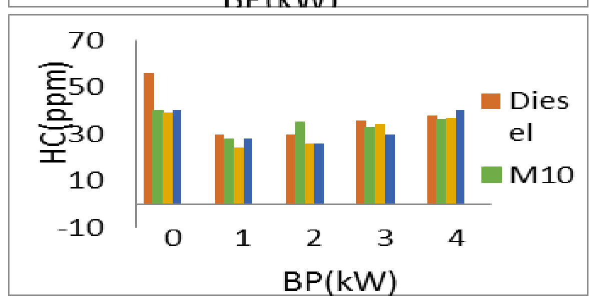




The variation of CO for different blends of MME and neat diesel fuel with different compression ratios. It is observed that the CO gradually decreases with increasing compression ratio. At maximum load with the compression ratio of 18, the CO for M10 is 0.03 % and 40% reduction of CO is achieved when 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.

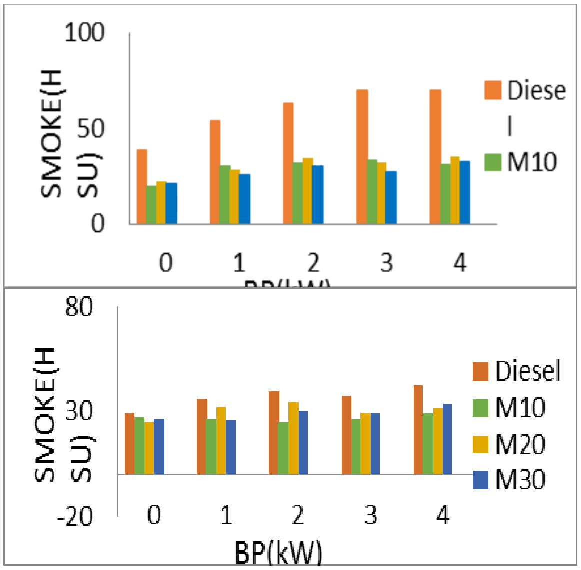
5.1.5 Hydrocarbon (HC)





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.

5.1.6 Smoke



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.

6. 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 B10.

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