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A COMPARATIVE STUDY ON CHARACTERISTICS OF RICE BRAN, POLANGA, KARANJA AND UPPAGE OIL METHYL ESTER FUELLED DI DIESEL ENGINE

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ABSTRACT

The present study objective is to compare the performance, emission and combustion characteristics of biodiesels such as rice bran oil methyl ester (RME), polanga oil methyl ester (PME), Uppage methyl oil methyl ester (UME), karanja oil methyl ester (KME) on direct injection (DI) diesel engine. From this comparative study it is found that PME showed better performance and emissions among the tested fuels when compared with baseline data of high speed-diesel at 80% load.

KEYWORDS: DI, KME, PME, RME, UME.

INTRODUCTION

Energy is an essential input for human being to develop in economical, social, and improving the quality of life. Energy demand is also growing at a faster rate with increasing trends of modernization and industrialization, and turned to focus on alternative fuels. Moreover, the availability of fossil resources diminished by day to day which drives to study on conventional diesel engine with the use of alternative fuels. For the past few decades, efforts have been made to commercialize various alternative fuels such as vegetable oil(soya bean oil , rapeseed oil, palm oil, sunflower oil, karanja, jatropha, polanga, rice bran, Moringa oleifera ,Uppage etc.), animal fat(beef tallow etc.),alcohol(Methanol, Ethanol), compressed natural gas, biogas, liquid petroleum gas, hydrogen.

Using of Vegetable oils in diesel engines is not a new concept. In 1900, 'Rudolf Diesel' demonstrated his first diesel engine run with peanut oil as fuel at the World Exhibition at Paris. However, due to enormous availability of petro-diesel, research activities on vegetable oil were not seriously pursued. Directly using of vegetable oils as fuel to run diesel engine is made a serious problems such as choking of injector, carbon deposits inside the cylinder more unburnt HC emissions due to its high viscosity. Hence it becomes necessary to convert the vegetable oils as methyl esters or ethyl esters to ensure the standards of ASTM protocol as fuel in diesel engine. Biodiesel fuel is an alternative, renewable, biodegradable, nonflammable, nontoxic green fuel. The common edible oils of biodiesel are palm oil, coconut oil, sunflower oil, and peanut oil etc., whereas Jatropha, Neem, Karanja, Rubber, Rice bran, Mahua, Moringa oleifera Polanga, Uppage etc. are the non-edible oil sources of biodiesel. Biodiesel is a renewable feed stock and as for as environmental concern it is clean burning free sulfur fuel.

Most of the researchers have reported that the performance of biodiesel fuelled diesel engine is poor than petro-diesel operated engine. Interestingly, some of the researchers have reported that thermal efficiency is higher with biodiesel than diesel fuel [1].The biodiesel operation reduces the harmful emissions viz., CO, HC and smoke but with little increment of NOx emissions relative to diesel fuel [2]. The biodiesel blends and neat biodiesel in diesel engine reduces carbon monoxides about 3-15% [3] unburnt hydrocarbons about 6-40% [4] and smoke density to 45% [5] compared to ULSD (ultra-low sulfur diesel). However, NOx increased up to 26% [6], BSFC increased by 6-15% [7] decreases in brake thermal efficiency up to 9% [8]. Fujia Wu et al. [9] reported that the NOx reduced in descending order are: CME, PME, SME, WME, and RME; PM emissions reduction varies from 53%-69%. Sahoo et al. [10] concluded that 50% jatropha biodiesel blend showed maximum power with less smoke amongst all the biodiesels and their blends than diesel. Agarwal et al. [11] reported that the rice bran biodiesel fuelled engines produce less CO, unburned HC, and PM emissions compared to diesel fuel but higher NOx emissions.

Palash et al. [12] observed that biodiesel blends have strong beneficial impacts on HC, CO and PM emissions but adverse effects on NOx emissions. Similar trends have also been reported by other researchers [13, 14]. Avinash et al. [15] observed that Calophyllum Inophyllum (polanga) biodiesel and additives showed BTE increased and lower in BSFC than diesel.

Table 1.

Important Properties of Test Fuels					
Property	HD	RME	PME	UME	KME
Density@15°C-kg/m3	840	875	870	860	881
LHV - MJ/kg	43.0	38.4	39.994	36.97	37.98
Kinematic Viscosity@40° C– cSt	2.5	4.9	4.35	5.2	4.3
Cetane Number	48	56	55	55	50.8

MATERIALS AND METHODS

Test Fuels

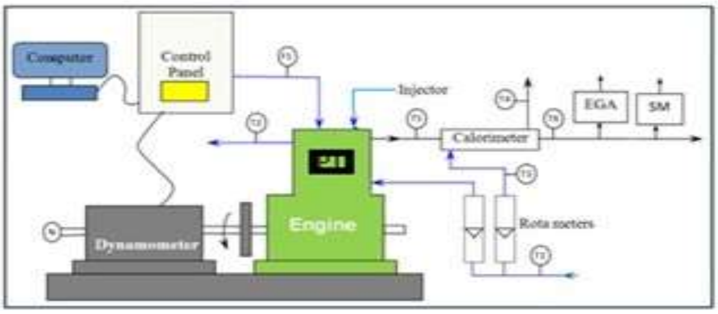
The test fuel samples in the present study have chosen as neat RME, PME, UME and KME and compared the results with HD fuel operation. The rice bran oil, polanga seed oil, uppage oil and karanja seed oil are the most suitable feedstock among the non-edible feed stocks in India. Some of the important properties of neat RME, PME, UME, KME and diesel fuel are given in Table 1.

Experimental Test Setup And Method

It has been found that no studies conducted on comparison of neat RME, PME, UME and KME fuels. The present comparative study analyzed on important performance parameters such as BTE, BSEC and emissions like CO, HC, NOx, and smoke opacity, and also while neat RME, PME, UME and KME fuels used in DICI engine.

Table 2

Specifications of Test Engine	
Type	Kirloskar, TV1,1 cylinder, 4-s, DI diesel engine
Injector opening pressure	200 bar
Rated power	5.2 KW (7 HP) @1500 RPM
Cylinder Bore	87.5 mm
Stroke length	110 mm
Compression ratio	17.5 : 1
Injection Timing	23° bTDC



T1, T3-Water inlet Temperature T4-Calorimeter exit temp.
T2-Engine water jacket outlet T6- EGT after Calorimeter
PT- Pressure transducer EGA-Exhaust gas analyzer
N-RPM encoder
Fig. 1 Schematic view of Engine Test Setup

The Test setup engine equipped with eddy current type dynamometer for loading and specifications of test engine is shown in table 2. Experimental set up is shown in Fig. 1. The setup equipped with the necessary arrangements to measure in cylinder pressure and crank-angle etc. The performance parameters like BP, BTE and BSEC can be evaluated by measuring the observations viz., speed and load on the engine, rate of fuel consumption, and airflow rate, with suitable instruments provided on the engine setup. The emissions directly measured with exhaust gas analyzer and Hartridge Smoke Meter. Each test conducted on engine after attaining steady condition only.

RESULTS AND DISCUSSION

Brake Thermal Efficiency (BTE)

The Fig.2 shows the effect of load on BTE for different test fuels. It is observed that the BTE is increased with load. However, the BTE is found to be high for all test fuels at 80% of full load than other loads. It may be the reason that better combustion and utilization of heat energy conversion into power at 4/5 of full load. The maximum BTE values are 30.25%, 25.3%, 25.41%, 24.67% and 24.3% for HD, RME, PME, UME and KME respectively, at 80% of full load.

Brake Specific Energy Consumption (BSEC)

The Fig.3 showed that the BSEC reduced with load for all test fuels. It is indicated that the lowest BSEC was noted as 11.9 MJ/kW-h, 14.3 MJ/kW-h, 14.2 MJ/kW-h, 14.59 MJ/kW-h and 14.8MJ/kW-h for HD, CRME, PME, UME and KME fuels respectively, at 80% of full load. However, the mean BSEC values in the order of 14.85 MJ/kW-h, 18.57 MJ/kW-h, 19.02 MJ/kW-h, 19.56 MJ/kW-h and 19.24 MJ/kW-h for HD, RME, PME, UME and KME fuels respectively. Higher BSEC value for biodiesels is caused to lower calorific value and higher viscosity than diesel fuel.

Carbon Monoxide (CO)

Fig. 4 represents carbon monoxide (CO) versus load for the different test fuels at standard operating conditions. It is observed the PME fuel showed lowest mean value 0.05%vol. amongst test fuels. The CO emissions are 0.1%v, 0. 07%v, 0.06%v, 0.08%v, and 0.08%v for RME, PME, UME and KME, respectively at 80% load. The CO emission is lowered by 30%, 33%, 27%, and18% for RME, PME, UME and KME, respectively, when compared to HD fuel, at 80% of full load. The CO emission is lower for biodiesels than diesel because of more complete combustion with their inbuilt oxygen content which reduces the possibility of forming a fuel rich zone in the combustion chamber.

Hydro Carbon (HC)

Fig. 5 shows the variation of HC emission for all test fuels at standard operating conditions. The HC emissions are higher at high loads due to low volumetric efficiency and more fuel injected into the cylinder. The mean HC values are 23.5ppm, 23.16ppm, 25.5ppm and 24.3ppm for PME, RME, UME and KME respectively; whereas it is 30.33ppm for high speed diesel fuel (HD).The HC emissions are found to be 40ppm, 28ppm, 29ppm, 32ppm and 27ppm for HD,PME, RME, UME and KME, respectively, at 80% of full load. The lower HC emission for biodiesels is due to more complete combustion of its higher oxygen content.

NOx

Fig. 6 shows the variation of NOx emission results for different test fuels with respect to different engine loads. The mean values of NOx emissions increased by 8.7%, 8.41%, 13.44%, and 12.37% for PME, RME, UME, and KME, respectively, in comparison with HD fuel. The NOx emissions are found to be 1080ppm, 1121ppm, 1139ppm, 1146ppm and1165ppm for HD, PME, RME, UME and KME, respectively, at 80% of full load. The higher NOx for biodiesel is attributed to higher temperature of combustion and the presence of oxygen with biodiesel.

Smoke Opacity

Fig.7 shows the smoke emissions verses engine load for different test fuels. It can be observed that the average smoke reductions for PME, RME, UME and KME are 32.28%,30.94%, 25.11%, and 23.31%, respectively, than those of high-speed diesel. The smoke emissions are found to be 46HSU, 34HSU, 35HSU, 37HSUand 33HSU for HD, PME, RME, UME and KME, respectively, at 80% of full load. The reason for the reduced smoke is due to the lower C/H ratio and no aromatic compounds as compared to diesel.

Combustion analysis

Combustion analysis is discussed in terms of HRR for different oil methyl esters and HD fuels. Fig. 8 represents the variation of maximum heat release rate with different load conditions for all test fuels. The Fig.9 indicated that there is a negative heat release rate for all test fuels and it is due to vaporization of heat required during ignition period. Due to the combined effect of low viscosity and high cetane number of the PME fuel when compared to other oil methyl esters, improved volatility, thereby better mixture formation with air during the ignition delay period. The peak heat release rates at 80% of full load for PME, CRME, KME, UME and HD fuels are 64.8, 63.4, 67.79, 66.64 and 79.01J/o CA, respectively.

Fig.10 depicts the variations of peak cylinder pressures with different load conditions. It is observed from the Fig.10 that the magnitude of peak cylinder pressure (PCP) increases as the load increases for all test fuels. Fig.11 shows the variation of in-cylinder pressure with respect to crank angle degree (240o-480o CA) for All fuels at 80% of full load.

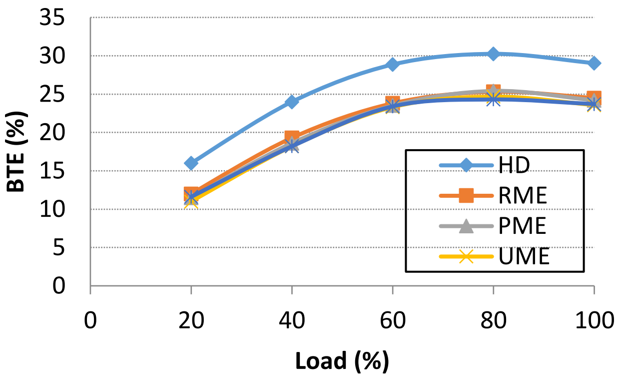


Fig.2 BTE vs. load for different test fuels

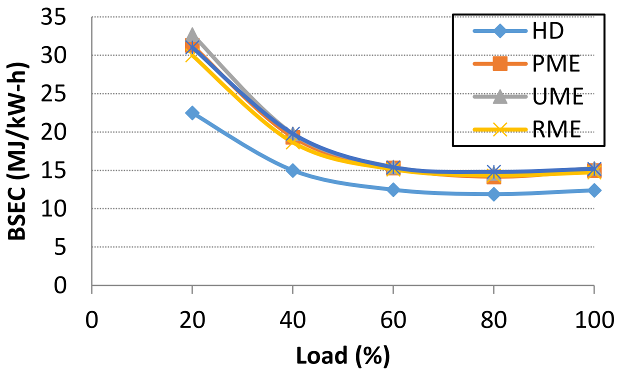


Fig.3 Variations of BSEC with load for different test fuels

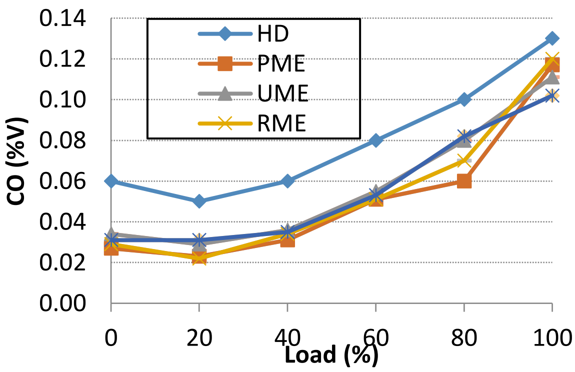


Fig.4 CO versus load for different test fuels

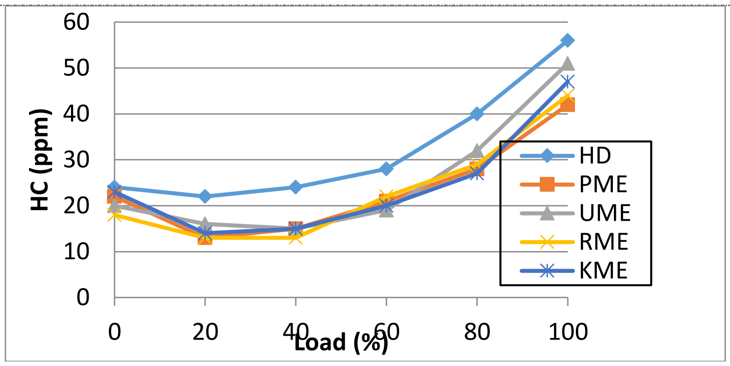


Fig.5 Variations of HC with load for different test fuels fuel

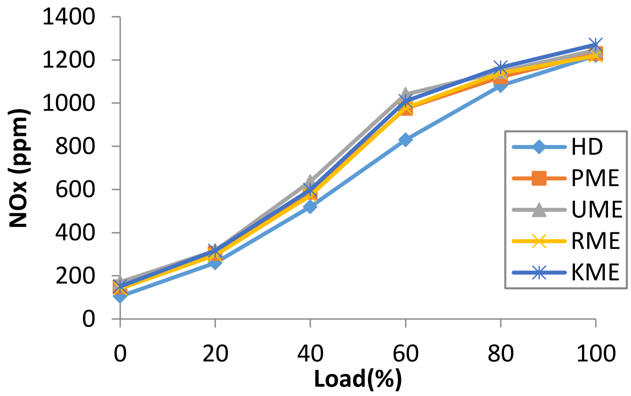


Fig.6 Variation of NOx with load for different test fuels fuel

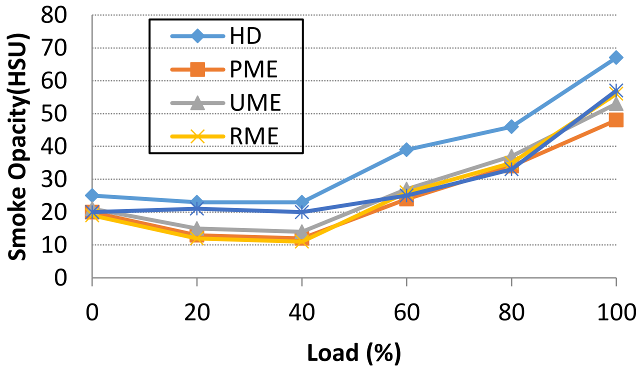


Fig.7 Smoke vs. load for different test fuels

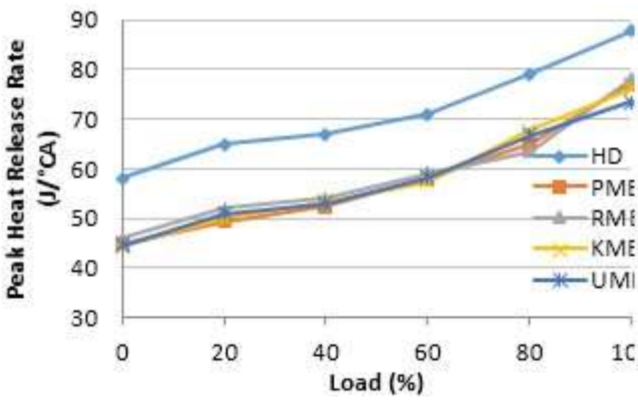


Fig.8 Peak HRR variation for different test fuels

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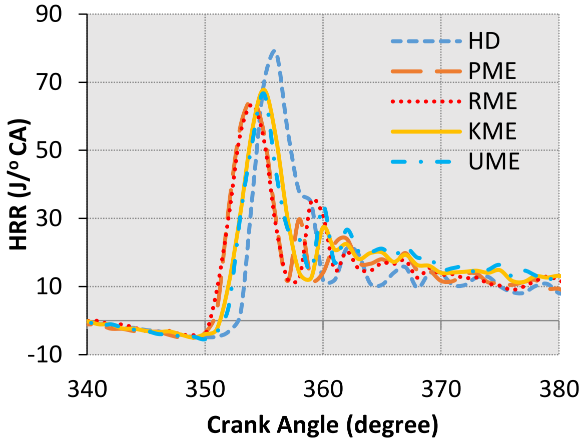

Fig.9 Variation of HRR for different test fuels at 80% load

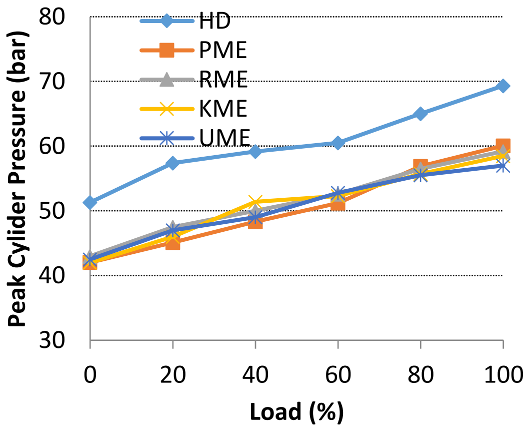

Fig.10 Variation of PCP for different test fuels

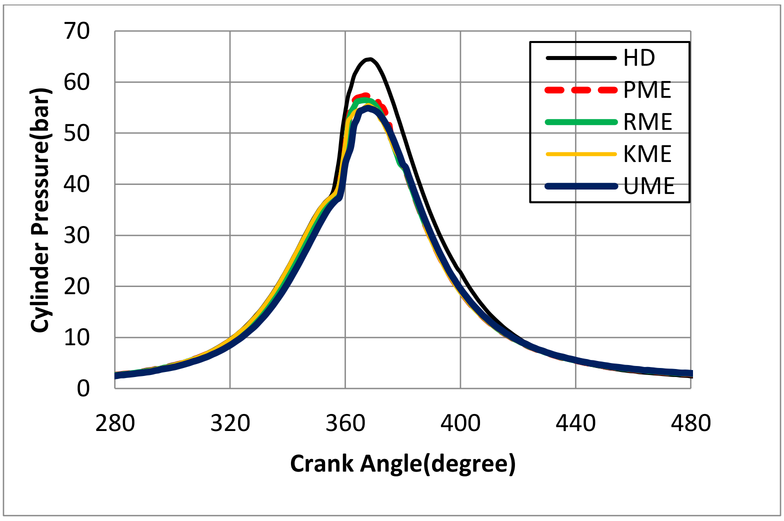

Fig.11 Variation of CP with CA for different test fuels at 80% load

CONCLUSION

Amongst the biodiesel fuels PME has shown overall better performance, combustion and emission characteristics when compared to the results with HD fuel, at 80% of full load, at standard operating conditions.

- The BTE is about 25.41% by and it is lowered about 4.84% than HD fuel normal engine operation.

- The BSEC is about 14.17MJ/kW-h and it is higher about 2.27 MJ/kW-h than HD fuel normal engine operation.
- The HC emission is noted as 28 ppm and reduction is about 22.22%.
- The CO emission is found to be 0.07%vol. and it is lowered by about 33%.
- The NOx emission is identified as1121ppm and increased about 3.7%.
- The smoke emission is about 34 HSU and it is lowered by about 26.08%.
- The peak cylinder pressure (PCP) is about 56.7bar and decreased by about 12.46%.
- The peak heat release rate (HRR) is found to be about 65J/oCA and decreased by about 17.73%.

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