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ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 3, Issue, 1, pp.45 - 49, January, 2012

International Journal of Recent Scientific Research

EXPERIMENTAL EXPLORATION OF CI ENGINE FUELLED WITH MAHUA OIL AND DIESEL WITH LOW HEATREJECTION TECHNIQUE AND BY VARYING INJECTION PRESSURE

[2]Mallikarjun, M.V.,[1]Venkata Ramesh Mamilla, and [3]Lakshmi Narayana Rao, G
[4]Purushothaman, K

[1]Department of Mechanical Engineering, St.Peter's University,Chennai.
[2]Department of Mechanical Engineering, St.Peter's University,Chennai.
[3] QIS Institute of Technology, Ongole,Andhra Pradesh
[4] St.Peter's University,Chennai

ARTICLE INFO

Article History:

Received 20th November, 2012
Received in revised form 10th December, 2012
Accepted 28th December, 2012
Published online 25th January, 2012

Key words:

Performance, emission, low heat rejection, injection pressure

ABSTRACT

The MI oil was tested by modifying the cylinder, piston head and valves coated with zirconium by plasma spray for low heat rejection (LHR). The neat oil was tested in the LHR engine and the performance and emission was studied at partial and full load conditions. At 75% load there found 25% better increment in brake thermal efficiency. Specific energy consumption decreased with increase in load. The variation of Carbon monoxide emission with respect to brake power was same for diesel and MI raw from no load to full load. . The reduction in HC was 40% at 75% of full load. The increase in NOx is due the high peak flame temperature during combustion. The increased power output means the reduced smoke which is due to LHR condition. Further the fuel was tested by varying the injection pressure from 200 bar to 400 bar insteps of 50 bar. The engine was running smooth and it developed pump and injector noise at 350 bar and 400 bar. Better the combustion lesser will be the fuel supply and efficiency increases. The BSEC decreased with increases in injection pressure. The change in injection pressure would change the injection pattern and better would be the combustion result in less/ reduced CO emission. The HC emission increases with increase in load at the same time HC level was showing a reduction as the injection pressure is increasing. The emission of NOx increases with increase in load, and also NOx increased with increase the injection pressure of the oil
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INTRODUCTION

Madhuca Indica is a botanical name of Mahua, also known as Mowrah in Hindi and Ippa in Telugu and Butter tree in English. The Madhuca Indica oil is obtained from the seeds of Madhuca Indica trees of two major species namely Madhuca latifolia (Roxb) Macbride and Madhuca longifolia (Koenig) Macbride; both belonging to the family of Sapotaceae. These two are so closely related that no distinction can be made in the trade of their seed or oil. It is a large deciduous tree and grows in semi arid, tropical and sub-tropical areas, in altitudes up to 1200 m. The tree grows up to 70 feet, matures in 8th year and yields fruits up to 60 years. It grows even on rocky, sandy, dry shallow soils and tolerates water logging conditions. The bark and root has medicinal value. The bark is also useful for dyeing and tanning. Madhuca Indica latifolia grows chiefly in Madhya Pradesh, Uttar Pradesh, Bihar, Gujarat, in parts of West Bengal, Maharashtra and South India. Madhuca Indica longifolia grows only in South India. The fruit of mahua is a good source of fatty oil known in commerce as Mahua butter. Fruits mature and fall during April to July in the North, August to September in the South. They are fleshy, green berry, yellowish or orange brown when ripe, 2.5 to 5 cm long. Latifolia oblong and Longifolia ovoid type fruits contain 1 to 4 tiny seeds. The yield per tree varies from 20 to 40 kg kernels. The dryings and decortification of the seed yield 70% kernel on the weight of seed. The oil content of kernel is about 46% in Latifolia and 52% in longifolia. The oil yield in an expeller is nearly 35% - 37%. The oil is extensively used in the manufacture of soaps and lubricating greases and for edible purposes. The fatty acid composition is Palmitic 24-25% Stearic 19-30% Oleic 36-43% Linoleic 8.9-15.8% and Arachidic 0-3.4%.

Experimental Set up details

The experimental set up consists of 3.7 KW single cylinder four stroke constant speed vertical water cooled direct injection type diesel engine was used for the study. The engine was coupled to a Generator and loaded by

* Corresponding author: +91 +9885183268
E-mail addres: maa_ram@yahoo.co.in,

electrical variable resistance loading device. The exhaust gas temperature was measured by an iron-constant thermocouple. The engine speed was measured by a hand tachometer. A mercury in glass thermometer was used to measure cooling water temperatures. Fuel consumption was measured using a burette and stopwatch. The exhaust emission such as CO2, CO, NOx and HC were measured by MRU (Germany) monitoring system.

Table 1 Basic Properties of Mahua Oil and Diesel

Properties	Unit	Ordinary Diesel	Mahua
Kinematic Viscociy at 30^0 C	mm^2/s	4.67	64.962
Sp. Gravity	--	0.834	0.91
Flash point	C	`54	186
Fire point	C	62	216
Calorific Value	Kl/kg	43600	37100

Table 2 Chemical Composition of Mahua Oil

S.no	Constituents	%	Molecular weight	Percentage
1.	Palmitic Acid	16-28.2	256.42	C-74.94, H-12.5,O-12.48
2	Stearic Acid	20-25.1	268.42	C-75.99,H-12.76,O-11.25
3	Oleic Acid	41.51	282.42	C-76.54,H-12.13,O-11.33
	Total		825.26	

RESULTS AND DISCUSSIONS

Madhuca Indica oil in LHR Engines

The Madhuca Indica oil was tested as fuel in D.I. diesel engine for performance and emission. This test was done to study the performance of the MI oil in the Low heat rejection engine. The experiment proved that the arrived results showed improvement in engine performance and emission. The fig shows the variation of brake thermal efficiency for MI oil in LHR engine with respect to brake power.

It is seen from the fig.1 that the BTE increase with increase in load. The BTE for raw oil was 19.98% at 75% of full load and 25.1% for LHR engine at 75% of full load. This showed an improvement in BTE by 25%.

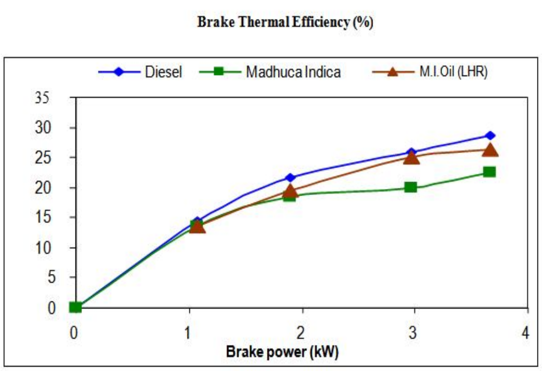

Fig.1 Brake thermal efficiency for LHR engine

The reason may be due to the insulation of cylinder wall, piston top surface, valves must have retained the heat. The high in cylinder temperature may be the reason for MI oil to vaporize better and faster and release heat energy efficiently. This trend continues from no load to full load.

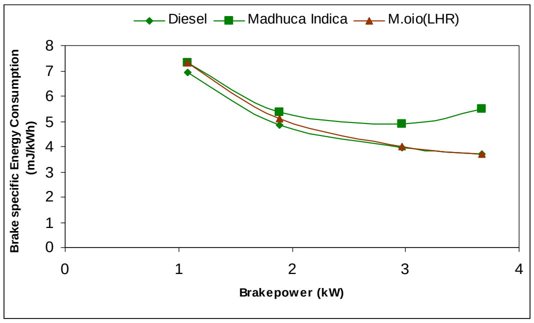

Fig. 2 BSEC for LHR engine

The Fig.2 variation of Brake specific energy consumption for MI oil in LHR engine diesel. The SEC decreases with increase in load. At higher loads the for example the sec was 4.9 at 75% of full load for MI oil and 3.98 for the same load for MI oil in LHR engine. It may be due to high temperature present in the cylinder must have caused the oil to vaporize better, mix better and released the energy.

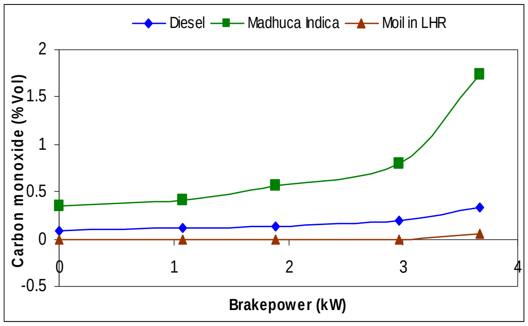

Fig.3 Carbon monoxide emissions for LHR engine

The fig.3 shows the variation of Carbon monoxide emission with respect to brake power. It is seen fro the figure that the figure that the trend for diesel and MI raw was same from no load to full load. But it is a almost a straight line seen from in the figure indicates the better combustion and at full load the emission was only 0.006% by volume. This is the indication of the better combustion due to ceramic insulated coating of the engine which has provided the favorable environment for MI oil to burn better.

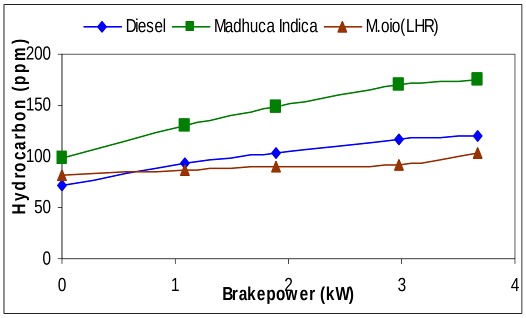

Fig.4 Hydrocarbon emissions for LHR engine

The fig.4 shows the variation of hydro carbon emission from MI oil in LHR engine with respect to load. It is seen from the figure that the HC increases with increase in load. Initially the HC was 98 ppm at no load to 104 ppm at 75% of full load for LHR engine. The reduction in HC was 40% at 75% of full load. The reduction in HC for LHR engine may be due to better combustion because for high cylinder wall temperature. The normal problem of higher HC emission for vegetable oil due to poor combustion is well tackled here by better combustion due to hotter environment.

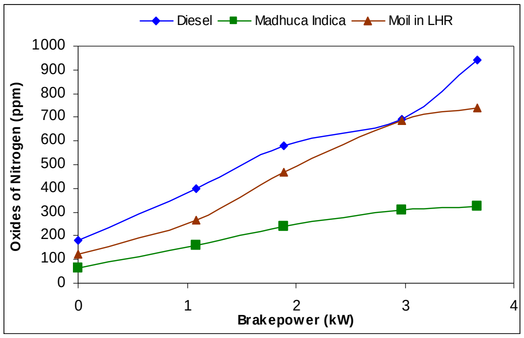

Fig.5 NOx emissions for LHR engine

The figure 5 shows the variation of emission of Oxides of Nitrogen with respect to load. It is seen from the figure that the NOx emission increases with increase in load. The Emission was 66 ppm at no load to 325 ppm at 75% full load for MI raw oil and 124 ppm at no load and 685 ppm at 75% of full load for LFR engine. The increase in NOx is due the high peak flame temperature during combustion. The raw oil in ordinary condition burn with low peak flame temperature whereas in LHR engine the MI oil vaporize better, mix well and produced high peak flame temperature and producing NOx emission.

The figure.6 shows the variation of smoke emission with respect to brake power. It is seen from the figure that the smoke emission increases with increase in load the MI oil in LHR engines emitted the same smoke level of 0.5 BSN as that of raw MI oil in ordinary engine.

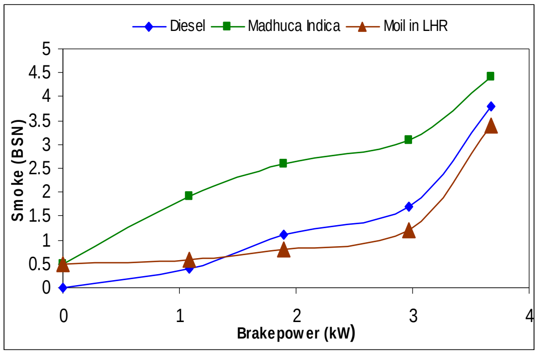

Fig.6 Smoke for LHR engines

It is seen further at 75% of full load MI oil in LHR engine produced only 1.2 BSN than 31 BSN for MI oil used in ordinary engine. The increased power output means the reduced smoke which is due to LHR condition. As far as the LHR engines is concerned with that of diesel due to high heat in combustion chamber.

Madhuca Indica oil varying injection pressure

Due to the high viscosity and high surface tension of the vegetable may cause a poor spray pattern. This may be lead to very poor combustion and release poor heat energy. In this investigation the Madhuca Indica oil is taken as an alternative fuel the fuel was tested by varying the injection pressure from 200 bar to 400 bar insteps of 50 bar. The engine was running smooth and it developed pump and injector noise at 350 bar and 400 bar. At four pressure the pumping elements are also modified At 400 bar pressure both pump and injector was very noisy. In this test the performance and emission test was carried out and discussed here. The figure 7 shows the variation of BTE for different fuel injection pressures for MI oil with respect to Brake power. It is seen from the figure that the brake thermal efficiency increases with increase in load.

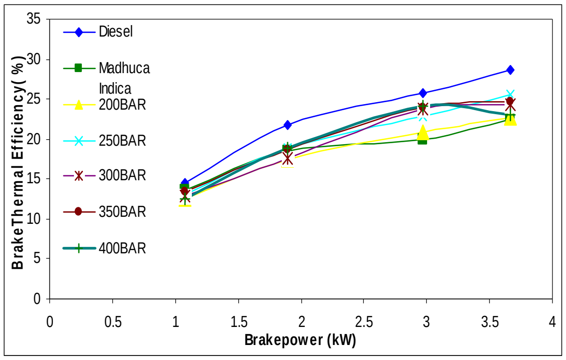

Fig.7 BTE for different fuel injection pressures for MI oil

As the injection pressure increases the spray pattern change and the particle size of the fuel droplet also refined. The ignition delay period also reduced with increase in injection pressure increases the noise also increased especially the fuel injection system (especially at 350 and 400 bar pressure) was developing more noise.

The BTE of diesel at 75 % of full load is 25.9%, for MI oil 19.8%, at 200 bar 20.8%, at 250 bar 22.77% at 300 bar 23.8%, at 350 bar 23.9% and at 400 bar 24.1%. If the injected spray is very fine the mixing of fuel with air inside the cylinder would be better and result in better combustion. Better the combustion lesser will be the fuel supply and efficiency increases.

The figure 8 shows the variation of BSEC with respect to brake power for different fuel injection pressure for MI oil. It is seen from the figure that the bsec decreases with increase in load. The BSEC decreases with increases in injection pressure. The BSEC reduced with increase in injection pressure. The BSEC measured at 75% of full load was 5.5 MJ/KWh for raw oil, 4.34 MJ/KWh at 200 bar, 4.39 MJ/KWh at 250 bar, 4.29 MJ/KWh at 300 bar, 4.31 MJ/KWh at 350 bar and 4.05 MJ/KWh at 400 bar. This really shows the energy released from the fuel injected into the engine.

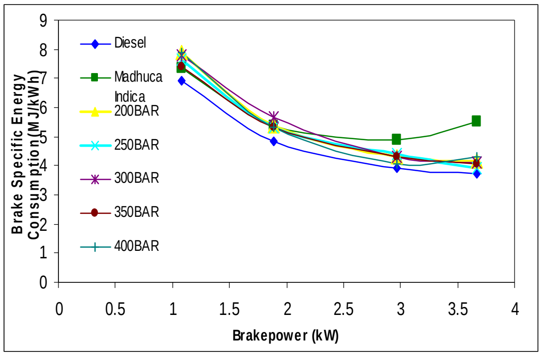

Fig.8 BSEC for different injection pressures of MI oil

For 400 bar injection pressure the minimum BSEC obtained than neat MI oil as shown in figure.

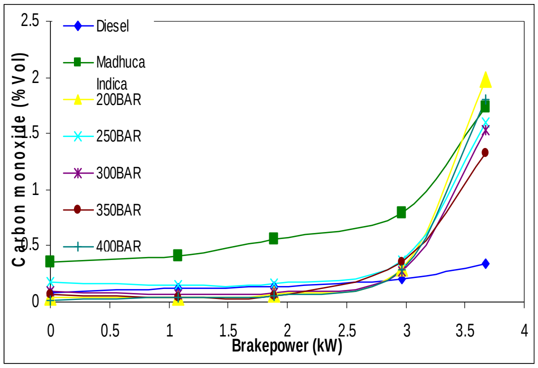

Fig.9 CO emission for different injection pressures of MI oil

The figure 9 shows the variation of Carbon monoxide emission for different injection pressure with respect to brake power. It is seen from the figure that the CO emission increases with increase in load. CO emission is the indication of incomplete combustion due to lack of oxygen. In case of diesel the CO emission will be normally very low. However for MI oil the CO emission at 75% of full load was 0.79% vol and the reduction of CO was 62% for 200 bar pressure, reduction of 53% for 250 bar pressure, and reduced by 60% for 300 bar pressure, reduction of 53% for 350 bar pressure, and reduction of 63% for 400 bar pressure. The reason may be the change in injection pressure would change the injection pattern and better would be the combustion Result in less/ reduced CO emission.

The figure 10 shows the Variation of Hydrocarbon for different injection pressures of MI oil with respect to brake power. The figure shows that the HC emission increases with increase in load at the same time HC level was showing a reduction as the injection pressure is increasing. The HC emission at 75% of full load the MI oil gave 170 ppm, 113 pm for 250 bar pressure, 75 ppm for 300 bar pressure, 61 ppm for 350 bar pressure, and 57 ppm for 400 bar pressure. The trend also clearly indicates the influence of the injection pressure for MI oil. This could have caused the oil to burn better and reduce the HC and Co emission to large extent.

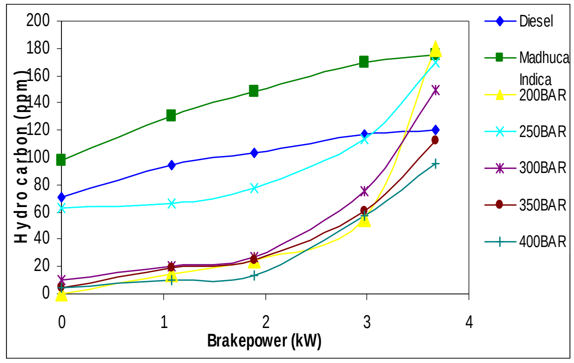

Fig.10 Hydro Carbon for different injection pressures of MI oil

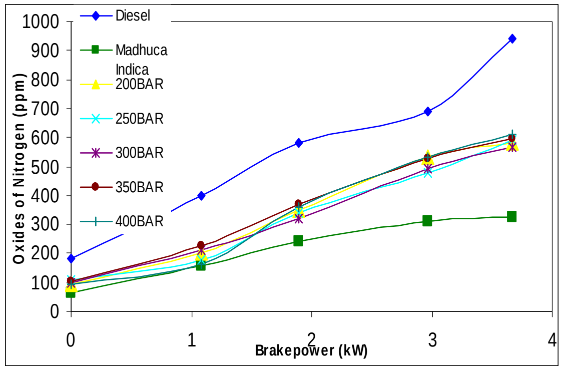

Fig.11 Oxides of Nitrogen for different injection pressures of MI oil

The figure 11 Oxides of Nitrogen for different injection pressures of MI oil with respect to brake power. It is seen from the figure that emission of NOx increases with increases in load, and also NOx in creases with increase the injection pressure of the oil The NOx emission trend lie in between the diesel emission and MI oil emission. The MI oil gave 310 ppm at 75% of full load, however at 250 bar pressure the increase in NOx was 53%, 58% for 300 bar pressure, 69% for 350 bar pressure, and 72% for 400 bar pressure. The increase in injection pressure causes reduced ignition delay, further the finely divided fuel droplets mix well with air and burn better and thus increasing the peak flame temperature hence the increase.

The figure 12 shows the variations of Smoke emission for different injection pressures of MI oil with respect to brake power. It is seen from the figure that the smoke increases with increase in load. It is also seen from the figure that the smoke is reduced with the increase in injection pressure. The high smoke emission for fuels like diesel which normally have hydrogen to carbons. MI oil smoke may due to is due to heavy unsaturated fatty compounds. The smoke from the MI oil was 3.2 BSN at 75% of load, 3BSN for 250 bar pressure, 2.9 BSN fro 300 bar pressure, 2.8 BSN for 350 bar pressure and 2.2 BSN for 400 BAR pressure. It may be due to refined injection, improved injection spray lead to better vaporizing and better mixing. Due to these reasons the combustion was better and smoke is reduced

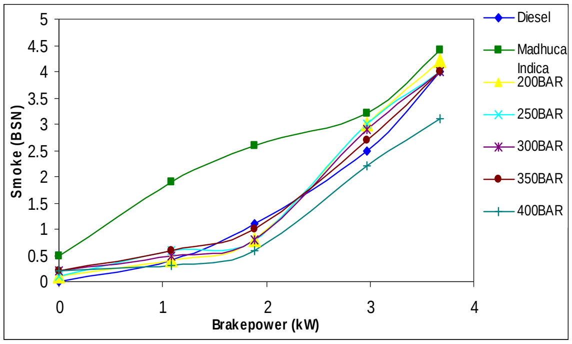

Fig.12 Oxides of Nitrogen for different injection pressures of MI oil

CONCLUSION

The experimental investigation was done on a single cylinder, water-cooled compressed ignition engine, which includes performance estimation at various loads and emission analysis allowing the engine to run on both the fuels diesel and mahua oil. As a first step the engine cylinder, piston head and valves were coated with zirconium by plasma spray for low heat rejection (LHR) and the performance indicating parameters like, brake power, brake thermal efficiency, brake specific energy consumption variation and exhaust emission levels were studied. It is observed that at partial load also there found better increment in brake thermal efficiency. Specific energy consumption decreased with increase in load. The variation of Carbon monoxide emission with respect to brake power was same for diesel and MI raw from no load to full load. The increase in nitrous oxides is due the high peak flame temperature during combustion. The increased power output means the reduced smoke which is due to LHR condition. Further the fuel was tested by varying the injection pressure from 200 bar to 400 bar insteps of 50 bar. The engine was running smooth and it developed pump and injector noise at 350 bar and 400 bar. Better the combustion lesser will be the fuel supply and efficiency increases. The BSEC decreased with increases in injection pressure. The change in injection pressure would change the injection pattern and better would be the combustion result in less/ reduced CO emission. The HC emission increases with increase in load at the same time HC level was showing a reduction as the injection pressure is increasing. The emission of NOx increases with increase in load, and also NOx increased with increase the injection pressure of the oil.

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