International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 9
September 2017

Experimental Investigation of Diesel Engine with Esterified Algae Oil

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ABSTRACT

In the present experimental research work, methyl ester of ALGAE oil is derived through transesterification of rice-bran oil using methanol in the presence of sodium hydroxide (NaOH) catalyst. Experimental investigations have been carried out to examine the combustion characteristics in a direct injection diesel engine running with diesel, biodiesel (ALGAE methyl ester), and its blends with diesel. Engine tests were performed at different engine loads ranging from no load to rated (100 per cent) load at constant engine speed (1500 rpm). A careful analysis of the cylinder pressure rise, heat release, and other combustion parameters such as the cylinder peak combustion pressure, rate of pressure rise, crank angle at which peak pressure occurs, and rate of pressure rise, were carried out.

All test fuels exhibited similar combustion stages as diesel; however, biodiesel blends showed an earlier start of combustion and lower heat release during premixed combustion phase at all engine load-speed combinations. The maximum cylinder pressure reduces as the fraction of biodiesel increases in the blend and, at higher engine loads, the crank angle position of the peak cylinder pressure for biodiesel blends shifted away from the top dead centre in comparison with baseline diesel data. The maximum rate of pressure rise was found to be higher for diesel at higher engine loads; however, combustion duration was higher for biodiesel blends.

INTRODUCTION

During the last decade the use of alternative fuel for diesel engines has received renewed attention. The interdependence and uncertainty of petroleum based fuel availability has created a need for investigating the possible use of alternative fuel. In recent years, the emphasis to reduce pollutant emissions from petroleum based engines has motivated the need for development and testing of several alternative fuels. The main pollutants from diesel engine are NO_X(Nitric Oxide& Nitrogen-dioxide) and particulate matter and smoke.

In order to reduce these harmful pollutants we have to go for an alternative fuel that would reduce these pollutants and also it could not emit other pollutant like Aldehydes, Ketones, etc., the alternative fuel aspiring to take this petroleum based fuels such as alcohol, LPG,CNG,LNG,Hydrogen,Vegetable Oils, Bio Gas, Producer Gas. Out of these gasses vegetable oils are long-term fuels and also these are renewable, recyclable fuel.

Vegetable oils can be directly used in compression ignition engine with out any modification. The primary problem associated with using pure vegetable oil as a fuel in a compression ignition engine is caused by viscosity. Vegetable oils present a very promising alternative to diesel oil since they are renewable and can be produced easily in rural areas where there is an acute need for modern forms of energy.

This was stated with remarkable foresight by none less than the inventor of the diesel engine, RUDOLF DIESEL. “The diesel engine can be fed with vegetable oils and would help considerably in the development of the countries which will use it. This may appear like a futuristic dream but I can predict with great conviction that this way of using a diesel engine may in future be of great importance”.

Quite obviously, only non -edible vegetable oils can be considered for this purpose. Particularly in nations like India, where edible vegetable oils are in great demand and far too expensive as fuel.

EXPERIMENTAL INVESTIGATION

TRANSESTERIFICATION PROCESS

Transesterification is most commonly used and important method to reduce the viscosity of vegetable oils. In this process triglyceride reacts

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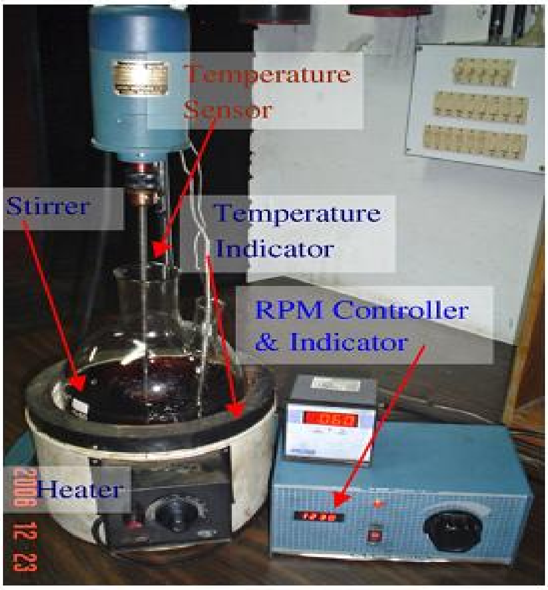
with three molecules of alcohol (Methanol) in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and glycerol. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called esterification. This esterified vegetable oil is called bio-diesel. Biodiesel properties are similar to diesel fuel. It is renewable, non-toxic, bio-degradable and environment friendly transportation fuel.

After esterification of the vegetable oil its density, viscosity, cetane number, calorific value, atomization and vaporization rate, molecular weight, and fuel spray penetration distance are improved more. So these improved properties give good performance in CI engine. Physical and chemical properties are more improved in esterified vegetable oil because esterified vegetable oil contains more cetane number than diesel fuel. These parameters induce good combustion characteristics in vegetable oil esters. So unborn hydrocarbon level is decreased in the exhaust.

It results in lower generation of hydrocarbon and carbon monoxide in the exhaust than diesel fuel. The vegetable oil esters contain more oxygen and lower calorific value than diesel. So, it enhances the combustion process and generates lower nitric oxide formation in the exhaust than diesel fuel.



Experimental set up.

Fig.1 Experimental setup

Gentle washing.

Fig.2 Experimental Setup

The engine used for the investigation is a single cylinder, four stroke, constant speed, vertical, water cooled, direct injection diesel engine.

ENGINE SPECIFICATION

Table. 1

Manufacturer	SPEED WELL
Type	TRB-DI
Model	SW-3B
Rated Power	5.9KW (8 Hp)
SFC	250 g/KWh
Speed	1500 RPM
Fuel	HSD
Lubrication Oil	HD-30
Number of Cylinder	1
Bore x Stroke (mm)	88 x110
Cycle	Four Stroke
Compression Ratio	16:1
Dynamic Injection Timing	12.6 o BTDC
Class of Governing	B1
Flywheel diameter	1.23 m

DYNAMOMETER SPECIFICATION

Manufacturer	- Benz Systems, Pune, India
Type	- Eddy Current Dynamometer
Model	- ECB – 70
SR.NO	- 9207
W (PAN) Max.	- 5
Dynamometer Constant	- 7026
BHP	- W (IND) x RPM / Dyn. Const.

Fig.3 Washing ALGAE oil

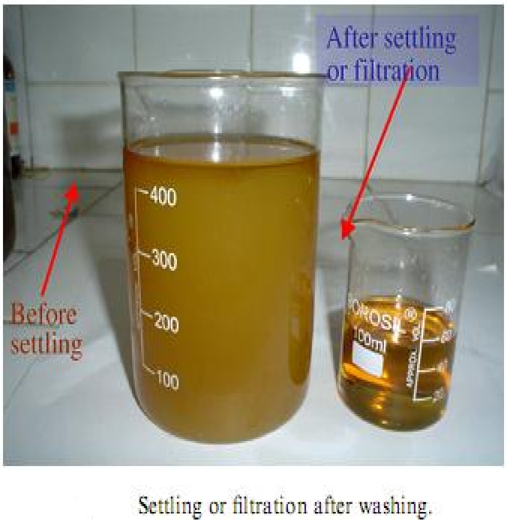


Fig.4 Esterified ALGAE oil

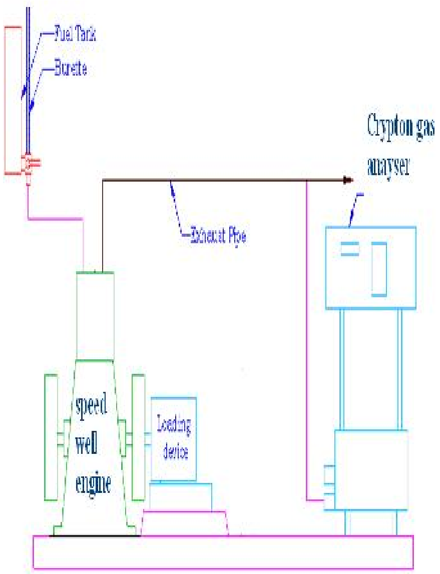


Fig.5 Experimental Set-Up


Fig.6 EXPERIMENTAL SETUP

Fig.7 PRESSURE CRANK ANGLE SETUP

Experimental Procedure

The speed well engine is mounted on the ground. Eddy current dynamometer was connected to the engine. Loading of the engine was done electrically with rheostat.Crypto gas analyzer connected to the exhaust pipe for measuring the HC,CO,NOx and CO_2.Measuring the time required for the 5 cc of fuel consumption with the help of burette setup.

The engine was started and warmed-up, at low idle, long enough to establish the recommend oil pressure, and was checked for any fuel, oil and water leaks. After completion of the warm-up procedure, the engine was run on no-load condition and the speed was adjusted to 1500 rpm by adjusting the fuel injection pump.

The engine was run to gain uniform speed after which it was gradually loaded. The experiments were conducted for six engine torque levels viz 0, 3, 6, 9, and 12 and 15 Nm. Also the experiments were conducted for B25, B50 B75& B100 fuel for the above said torque levels for same compression ratio.

For each load condition the engine was running at a minimum of 5 minute and data were collected during the last 2-minute of operation. Simultaneously, engine exhaust emission (NO_X, CO, HC and CO_2) was determined.

An eddy current dynamometer has been coupled to the engine to apply the load / torque on engine.The fuel flow rate was measured by timing the consumption for known quantity of fuel (5 cc) from a burette.

An instrument called Crypton Gas Analyzer is used to measure directly the exhaust gas emissions such as CO_2 in terms of % by volume, CO in terms of % by volume, HC in terms of ppm, NO_X in terms of ppm.

RESUULTS AND DISCUSSIONS

PERFORMANCE CHARACTERISTICS

1. TOTAL FUEL CONSUMPTION

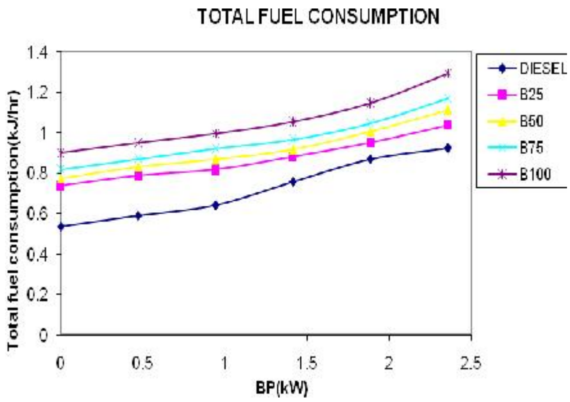


Fig 8.1 TFC VsBP

TFC for B25 is nearer to the diesel .It can be observed that the fuel consumption is the highest in the case of B100 fuel, because the calorific value is lower for the bio-diesel produce from ALGAE oil .

2. SPECIFIC ENERGY CONSUMPTION

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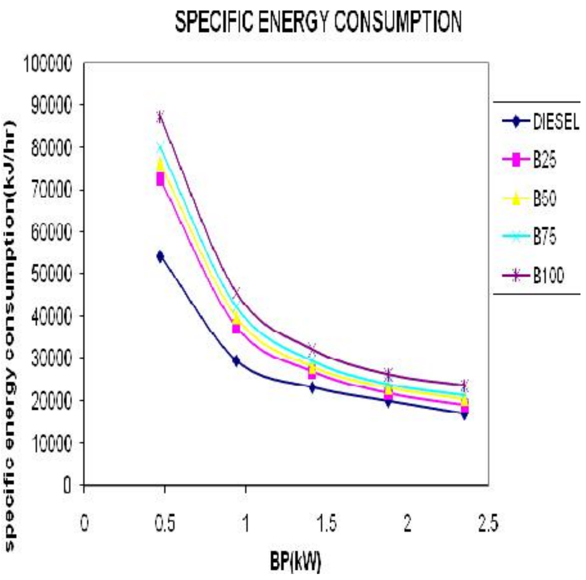

Fig8.2 SEC Vs BP

It can be seen that the Specific Energy Consumption is higher in the case of B100 and lower for B25.

3. SPECIFIC FUEL CONSUMPTION

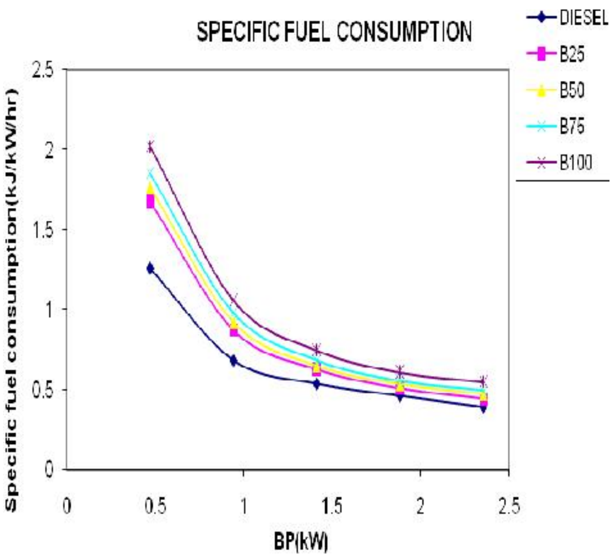

Fig 8.3 SFC Vs BP

It can be seen that the Specific Fuel Consumption is higher in the case of the B100 and lower for B25.

4. BRAKE THERMAL EFFICENCY

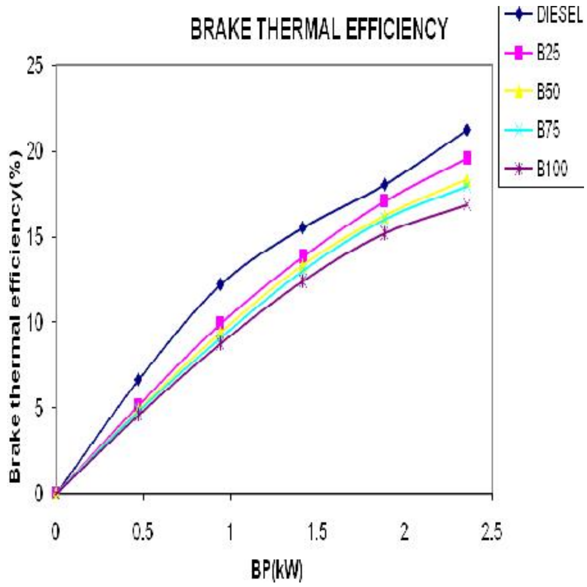

Fig 8.4 BTE Vs BP

It can be seen that Efficiency of the engine with B25 is closer to diesel. The thermal efficiency is lower for B100 and it is 5.54%. This is also due to low heating value of Bio-diesel.

5. MECHANICAL EFFICENCY

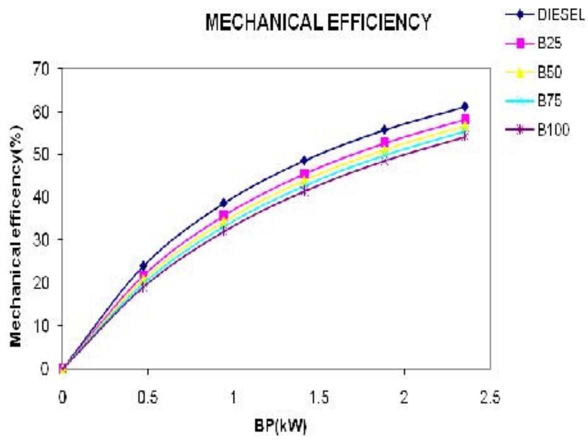

Fig 8.5 M E Vs BP

It is also observed that mechanical efficiency of B25 is similar to diesel. The experimental investigations revealed that the overall combustion characteristics were quite similar for for bio diesel and diesel.

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ISSN 2394 – 3386
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EMISSION CHARECTERISTICS

1.HYDRO CARBON EMISSION

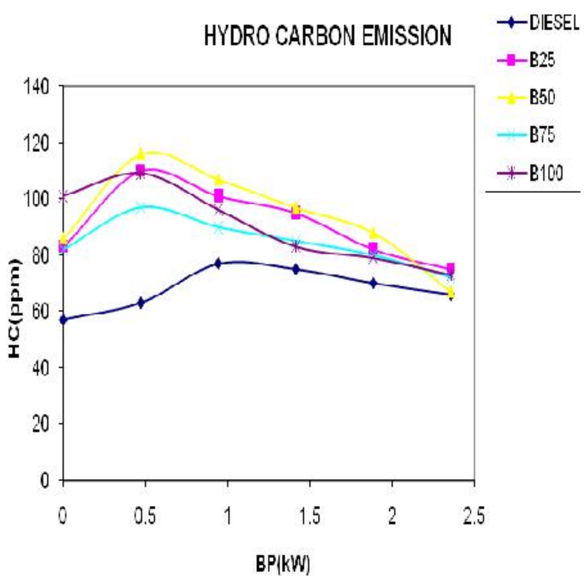

Fig 9.1 HC Vs BP

The emission of UBHC form the engine with B25 is slightly higher than diesel and forB75, HC emission decreasing gradually. Diesel and B100 have higher Hc emission because of incomplete combustion.

2. OXIDES OF NITROGEN

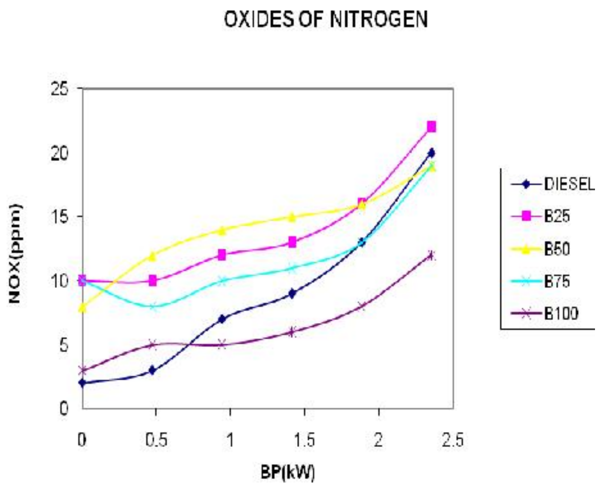

Fig 9.2 Nox Vs BP

Nox content for the B50 is higher than ALGAE oil blends. Diesel and B100 are having minimum Nox content compare to other blends of bio-diesel fuels.

3. CARBON MONO-OXIDE AND CARBON DI-OXIDE

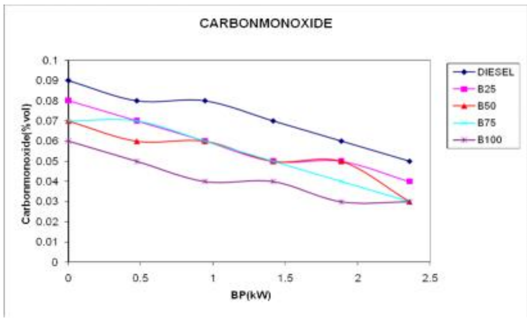

Fig 9.3 CO Vs BP

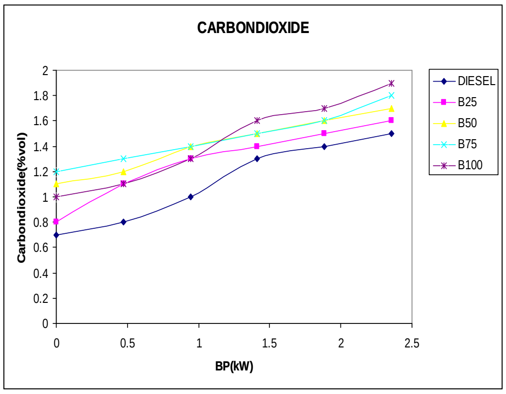

Fig 9.4 CO_2 Vs BP

It is perceive that, emission of CO and HC is lower, but CO2 is higher in exhaust gas when B100 than B25, B50, and B75. This shows that, better combustion takes place while using B25 as a fuel.

COMBUSTION ANALYSIS

1. PEAK PRESSURE

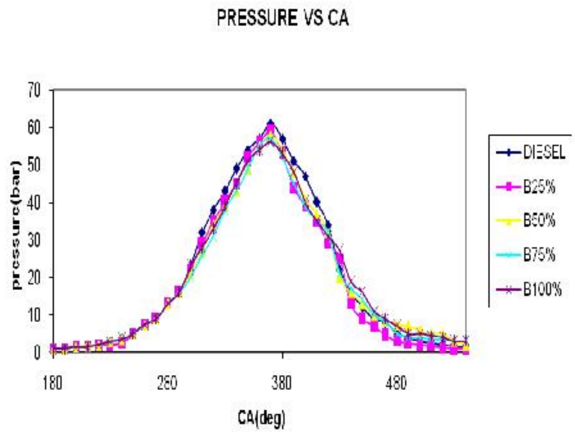

FIG 10.1Peak Pressure with respect to Crank Angle

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Peak Pressure for diesel 65 bar and B25 is 62 bar and the delay period for bio diesel is more than the diesel, This is because of density and calorific value of bio fuels are less than diesel.

2. HEAT RELEASE RATE

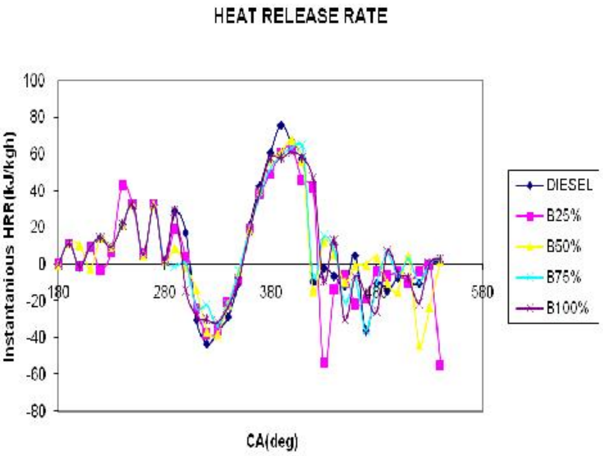

FIG 10.2 Variation of HRR with respect to Crank Angle

Heat Release rate for diesel is 80J/degCA andfor B25 is 60J/degCA. Heat release rate for other blends are lesser than diesel due to its Calorific Value difference.

3. CHANGE OF PRESSURE

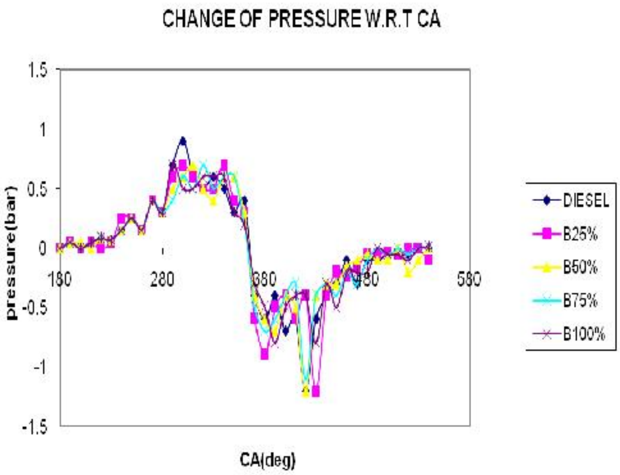

FIG 10.3 Change of Pressure with respect to Crank Angle

The maximum pressure change for B25 occured at crank angle 360 degree around 1 bar. Diesel and other blends having less rate of pressure change over the various crank angles.

4. CUMULATIVE HEAT RELEASE RATE

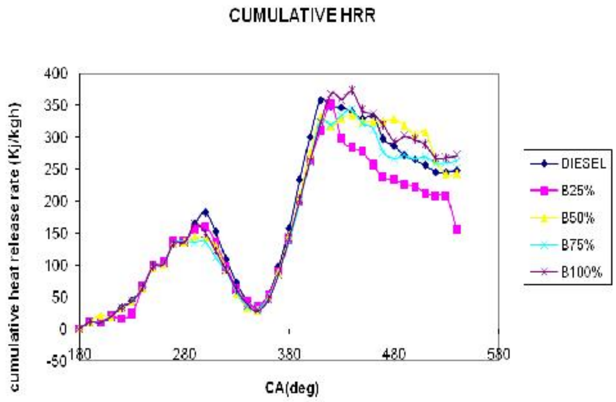

FIG 6.4 Variation of Cumulative Heat release Rate with respect to Crank Angle

Overall heat release for diesel is 350 J/deg and next to that B25 and B100 having the maximum value. Other blends are have less cumulative heat release rate, because it has lesser calorific value than diesel.

CONCLUSION

A single cylinder four stroke compression ignition engine was operated successfully using 100% pure diesel B25, B50, B75, andB100 as a fuels. A detailed experimental analysis for finding out the combustion characteristics of bio-diesel in comparison with diesel was carried out. Various combustion parameters such as performance and emission were evaluated for different engine loads as a constant engine speed of 1500 RPM in a stationary diesel engine. The experimental investigations are summarized as follows,

- The increase in engine torque decreases BSFC, while at the same time an increase in Brake Thermal Efficiency observed for all kinds of fuel.
- It is noticed, B25 gives approximately same Brake Thermal Efficiency to diesel, B50, B75, B100 at peak loads and part load conditions have same value.
- B25 and diesel have similar performance characteristics at most of the loads.
- It can be observed that the fuel consumption is the highest in the case of B100 fuel, because

the calorific value is lower for the bio-diesel produce from ALGAE oil.

- TFC for B25 is similar to diesel.
- It can be seen that the Specific Energy Consumption is higher in the case of B100 and lower for B25.
- It can be seen that Efficiency of the engine with B25 is closer to diesel. The thermal efficiency is lower for B100 and it is 5.4%. This is also due to low heating value of Bio-diesel.
- It is also observed that mechanical efficiency of B25 is similar to diesel. The experimental investigations revealed that the overall combustion characteristics were quite similar for bio diesel and diesel.
- The emission of UBHC form the engine with B25 is slightly higher than diesel and forB75, HC emission decreasing gradually. Diesel and B100 have higher HC emission because of incomplete combustion
- Nox content for the B50 is higher than ALGAE oil blends. Diesel and B100 are having minimum Nox content compare to other blends of bio-diesel fuels.
- Bio-fuels of ALGAE esters did not cause any combustion related problems.
- It is perceive that, emission of CO and HC is lower, but CO_2 is higher in exhaust gas when B100 than B25, B50, and B75. This shows that, better combustion takes place while using B25 as a fuel.
- Peak pressure for diesel is 65 bar and for B25 it is around 62 bar. The delay period for bio-diesel is more than diesel, this is because of density and calorific value of bio-fuels is less than diesel.
- Heat Release rate for diesel is 80J/degCA and forB25 is 60J/degCA
- Heat release rate for other blends are lesser than diesel due to its Calorific Value difference.
- This detailed experimental investigation confirms that bio-fuels of ALGAE oil methylesters can substitute mineral diesel without any modification in the engine.

REFERENCES

1. A.S Ramadhas, S.Jayaraj, C. Muraleedharan , "Use of Vegetable Oils as I.C engine Fuels : A Review", Renewable Energy, Vol. 29, 2004, 727-742.
2. B.K. Barnwal, M.P. Sharma , "Prospects of biodiesel production from vegetable oils India," Renewable and Sustainable Energy Reviews, Vol. 9 ,2005, 363-378.
3. D. Agarwal, L. Kumar, A.K. Agarwal, "PerformanceEvaluation of a Vegetable oil fuelled CI Engine". RenewableEnergy, accepted 29th June 2007.
4. R. Sarin, M. Sharma, " Jatropha Palm biodiesel blends: Anoptimum mix for Asia", FUEL, Vol. 86, 2007, 1365-71.
5. M.S. Kumar, A.Ramesh A , "An experimental comparison of methods to use methanol and Pongamia oil in a compression ignition engine", Biomass and Bio Energy, Vol.25 2003, 309-318.
6. Wincentry Lotko, Technical University of Radom, “ The effect of Rapseed oil Diesel oil mixture composition and particulate Matter emission level in diesel engine”, SAE 2001-01-3388
7. Shailendra Sinha ,Avinash Kumar Agarwal, Indian Institute of Technology Kanpur, “Combustion Characteristics of Rice Bran Oil-Derived Biodiesel in a Transportation Diesel Engine”, SAE 2005-26-354
8. Energy Conversion & Management ., Vol 49, Issue 5, May 2008., Pages 1248-1257.
9. Energy Conversion & Management ., Vol 88, Issue 6, June 2008., Pages 1031-1041.

Table .2 Properties of Rice Bran Oil and Diesel

Chemical and physical properties of rice bran oil

Fatty acids (%)[a]	
Palmitic C16:0	18.8
Stearic C18:0	2.4
Oleic C18:1	43.1
Linoleic 18:2	33.2
Linolenic 18:3	0.6
Arachidic C20:0	0.7
Free fatty acids (%)	2.8
Density (kg/m^3)	922
Kinematic viscosity@40 °C (cSt)	43.52
Kinematic viscosity @100 °C (cSt)	9.21
Flash point/fire point (°C)	316/337
Cloud point/pour point (°C)	13/01

[a] Source: Srivastava and Prasad [2].

Fuel specifications of rice bran oil, rice bran oil methyl ester and mineral Diesel

Property	Test procedures	Diesel	Rice bran oil	Rice bran oil methyl ester
Specific gravity @ 30 °C		0.839	0.920	0.877
Kinematic Viscosity @ 40 °C (cSt)	ASTM D445	3.18	43.52	5.29
Cetane Number	ASTM D613	51	50.1	63.8
Cloud Point (°C)	ASTM D2500	6	13	9
Pour Point (°C)		−7	1	−2
Flash Point (°C)	ASTM D93	68	316	183
Fire Point (°C)		103	337	196
Conradson Carbon Residue (%, w/w)	ASTM D 189	0.1	0.6	0.35
Calorific Value (MJ/kg)	ASTM D 240	44.8	41.1	42.2
Elemental analysis (% w/w)	C	83	74.13	72.96
	H	13	11.0	12.73
	N	1.76	1.34	0.94
	O	0.19	12.25	11.59
	S	0.25	ND	ND

ND = Not detected.

Table .3 Properties of various blends of Rice Bran Oil

BLEND	CV(KJ/Kg)	DENSITY (g/cc)
B25	42950	0.849
B50	42200	0.877
B75	41920	0.906
B100	41100	0.920