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Experimental investigation on performance and emission characteristics of diesel - Jatropha methyl ester blends fueled diesel engine at optimum engine operating parameters

M. VENKATRAMAN[1] and G. DEVARADJANE[2]

[1]Department of Mechanical Engineering, Arulmigu Meenakshi Amman College of Engineering,Vadamavandal,Kanchipuram - 604 410 (India).
Email:mvramcet@yahoo.co.in
[2]Department of Automobile Engineering, Anna University, MIT Campus, Chrompet, Chennai-600 044 (India).

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ABSTRACT

In the present investigation, tests were carried out to determine engine performance, combustion and emissions of a naturally aspirated direct injection diesel engine fueled with diesel and Jatropha Methyl ester and their blends (JME10, JME20 and JME30). Comparison of performance and emission was done for different values of compression ratio, injection pressure and injection timing to find best possible combination for operating engine with JME. It is found that the combined compression ratio of 19:1, injection pressure of 240bar and injection timing of 27°bTDC increases the BTHE and reduces BSFC while having lower emissions.From the investigation, it is concluded that the both performance and emissions can considerably improved for Methyl ester of jatropha oil blended fuel JME20 compared to diesel.

Key words: Diesel engine, injection timing, injection pressure, *Jatropha* oil, methyl esters.

INTRODUCTION

The increase in number of automobiles in recent years has resulted in great demand for petroleum products.Vegetable oils might provide a viable alternative to diesel since they are renewable in nature and environmentally friendly. The use of vegetable oil in engines without any modifications results in poor performance and emissions. Transesterification method is used to reduce the viscosity of the vegetable oil and solves the most of the problems of raw vegetable oil.Transesterification is the reaction wherein the vegetable oil is transesterified with alcohol and the process of removal of glycerol from fatty acids. This esterfied vegetable oil is called biodiesel.In the present investigation biodiesel was prepared from jatropha oil and the blend with diesel in various volumetric proportions the prepared blends were fueled in the engine test rig. The performance, combustion and emission characteristics were analysed on a four stroke single cylinder direct injection diesel engine.The properties of Jatrophamethylester and raw oil are compared with diesel as shown in Table.1.

EXPERIMENTAL

Fig.1.shows the schematic line diagram of the experimental set up and its specification are given in Table .2. A Electrical dynamometer was used to apply the load on the engine. A water rheostat with an adjustable depth of immersion electrode was provided to dissipate the power generated.Tests were carried out at various loads starting from no load to full load condition at a constant rated speed of 1500 rpm. At each load, the fuel flow rate various constituents of exhaust gases such as Hydrocarbon (HC), carbon monoxide (CO) and nitrogen oxides (NO_x), were measured with a 5-gas MRU elta exhaust gas analyzer. The analyzer uses the

principle of non-dispersive infrared (NDIR) for the measurement of CO and HC emissions while NO_x measurement was by means of electrochemical sensors. Combustion analysis was carried out by means of an AVL pressure pick-up fitted on the cylinder head and a TDC encoder fixed on the output shaft of the engine. The pressure and the crank angle signals were fed to a pentium personal computer. Various combustion parameters like heat release rate, cumulative heat release rate and peak pressure and its accurance were obtained using data acquisition system. The engine was first operated with diesel oil to generate the baseline data followed by Methyl Esters Jatropha and their blends such as JME10, JME20 and JME30 blends.

RESULTS AND DISCUSSIONS

Testing were carried out at different compression ratio, injection timing and injection pressure and its details have been mentioned in Table 3. At injector opening pressure 200bar and 220bar and injection timing of 21°bTDC and 24°bTDC and compression ratio 17.5:1 and 16:1 were tried for diesel and different biodiesel blends but from the investigation it was found that the performance and emission was very poor. Further the engine were set to run at higher compression ratio of 19:1,advanced injection timing of 27°bTDC and higher injector opening pressure of 240bar it arrives at the optimum range operating parameters for diesel and jatropha methyl esters JME20. It was found that (JME20) it gives better performance and emissions for the optimized operating parameters.

Fig. 2 shows the variation of brake thermal efficiency with brake power for different fuels.The maximum brake thermal efficiency obtained is about 30,9% for JME20 and 30.1% for diesel.Increase in thermal efficiency is due to percentage of oxygen presence in the biodiesel and a rapid change in combustion behaviour of the blend.The addition of JME20 with diesel changes reduces ignition delay and reduces the burn duration.Hence the injected fuel completes its combustion closer to the TDC and shorter than diesel baseline.The increase in air

Table 1: Comparison of biodiesel properties with diesel

Properties	Diesel	Jatropha oil	Bio-Diesel (Jatropha Methyl Ester)
Cetane No.	45 – 55	41	52
Density(kg/m^3)	821	907	881
Viscosity (cSt)	3.52	36.9	5.12
Calorific value (MJ/kg)	43	41.1	41.6
Flash point ^{0}C	48	276	152
Oxygen %w	1.19	11.06	10.97

Table 2: Specifications of engine

Make	Kirloskar
Model	TAF 1
Type	Direct injection, air cooled
Bore × Stroke (mm)	87.5 × 110
Compression ratio	17.5:1
Cubic capacity	0.661 lit
Rated power	4.4 KW
Rated speed	1500 rpm
Start of injection	24° bTDC
Connecting rod length	220 mm
Injector operating Pressure	220 bar

Table 3: Operating parameters considered in the present Investigations

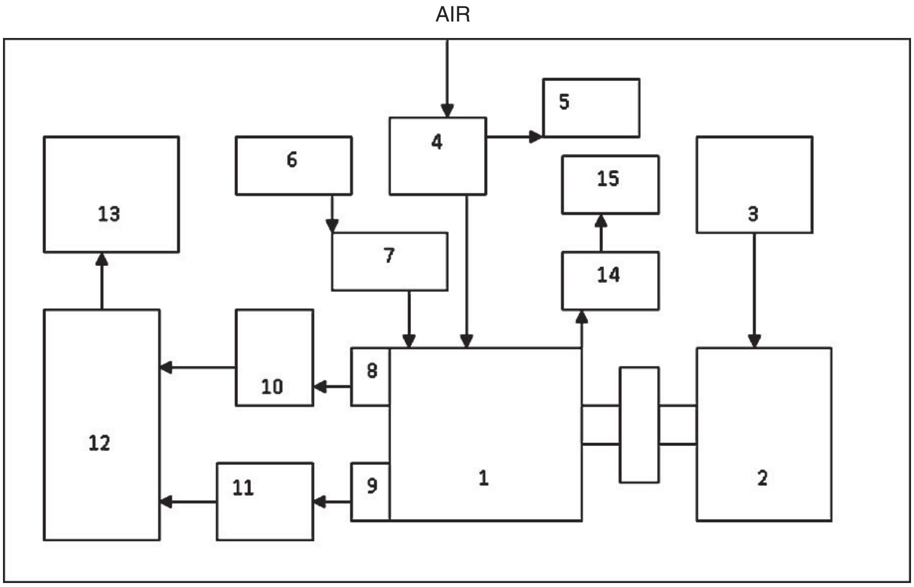
% Load	0,25,50,75,100
Speed (rev/min)	1500
Compression ratio	16:1,17.5:1,19:1
Injection Timing°bTDC	21,24,27
Injection Pressure(bar)	200,220,240

entrainment and rapid release of heat from the first stage of combustion could be the additional reason for the higher brake thermal efficiency JME20.

Fig.3 shows the variation of brake specific fuel consumption with brake power for different biodiesel blends.It can be observed that the bsfc of 0.273 kg/kW-hr was obtained for diesel and 0.27 kg/kW-hr for JME20.This is due complete combustion of JME20 because of presence of high cetane of JME as a result lower BSFC of JME20.

Fig.4. From the results it is found that JME20 offers comparatively lower BSEC than the other fuels. This is due to better combustion of JME20 due to presence of high Cetane of JME. JME30 fuels are containing higher proportions of JME and this reduces the heat content of fuel. This may be the main reason for higher BSEC of this fuel.The presence of lower fraction of JME enhances the combustion behaviour of diesel and releases its heat within a shorter duration than the diesel operation. This is the main reason for lower BSEC of JME20.

Fig.5.Shows the variation of hydrocarbon for different biodiesel blends at rated speed with respect to brake power. Diesel offers the maximum rate of hydrocarbon emission 36ppm among the tested fuels. Other fuels are offering relatively lower HC emissions due to the presence of high cetane of JME. The addition of JME with diesel fuel enhances the combustion of fuels and improves better reaction with the air presence inside the cylinder. The higher compression ratio, injection pressure and more advanced injection timing helps to provide clean combustion than the other operating parameters. Hence JME blended fuels perform better at this setting and completes its combustion and liberates its heat in shorter duration. This may be the additional reason for lower HC emission of JME blended fuels.



1. Diesel Engine
2. Electrical Dynamometer
3. Dynamometer Controls
4. Air box
5. U- Tube manometer
6. Fuel tank
7. Fuel flow meter
8. pressure transducer
9. TDC position sensor
10. Charge amplifier
11. TDC amplifier circuit
12. A/D card
13. Personal computer
14. Exhaust gas analyzer
15. AVL smoke meter

Fig. 1: Experimental setup

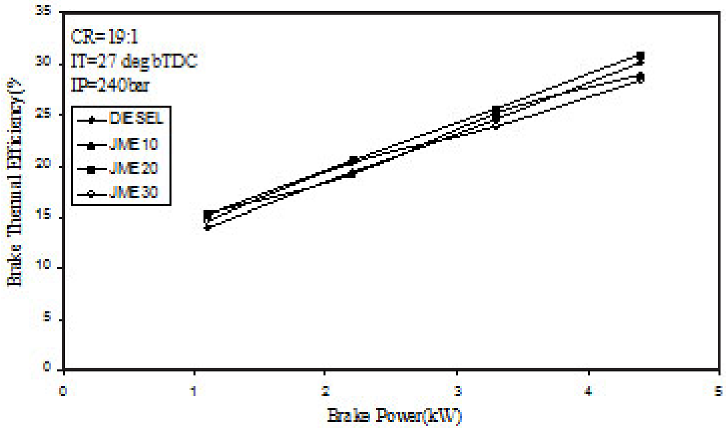


Fig. 2: Variation of Brake Thermal Efficiency with brake power

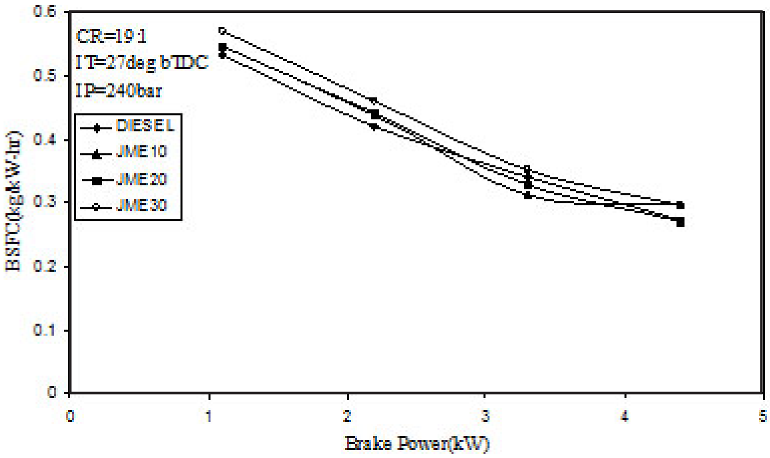


Fig. 3: Variation of BSFC with brake power

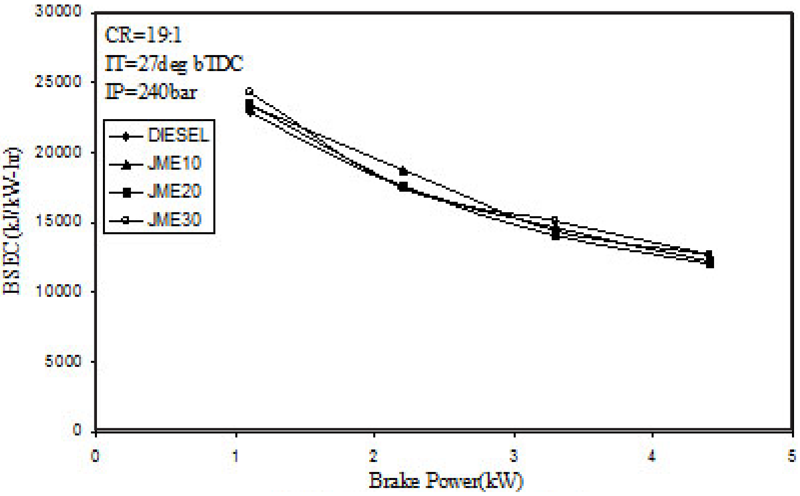


Fig. 4: Variation of BSFC with brake power

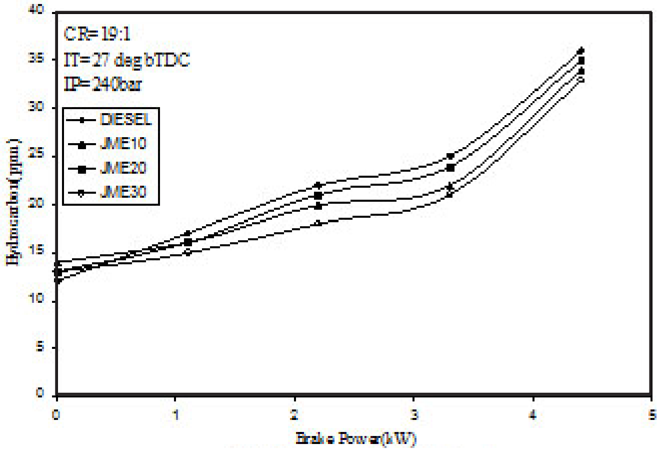


Fig. 5: Variation of HC with brake power

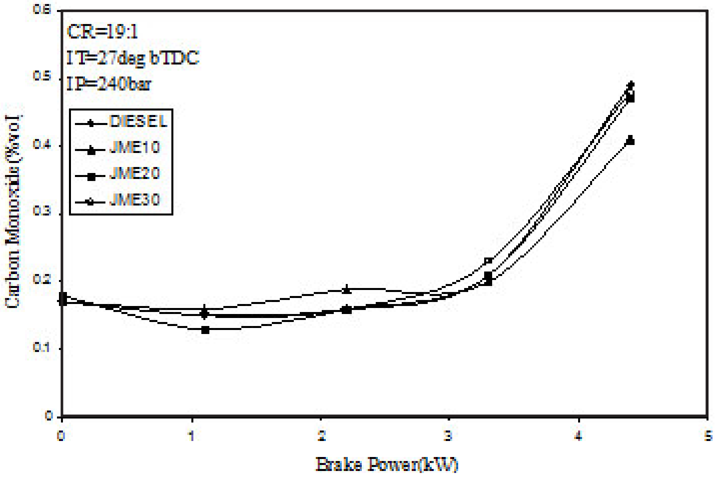


Fig. 6: Variation of carbon monoxide with brake power

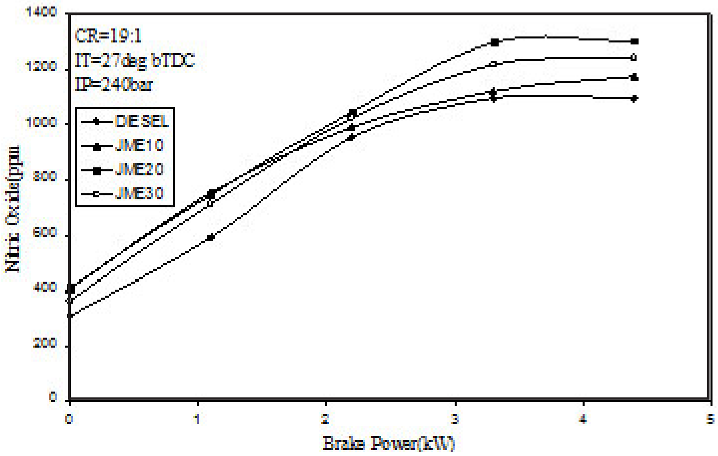


Fig. 7: Variation of Nitric oxide with brake power

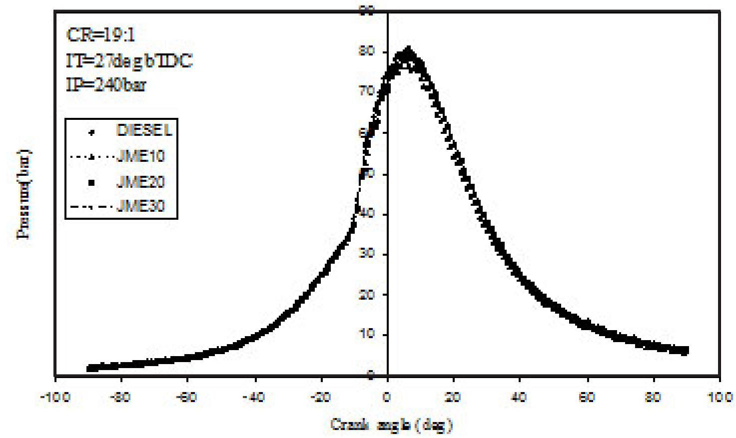


Fig. 8: Variation of Cylinder pressue with crank angle

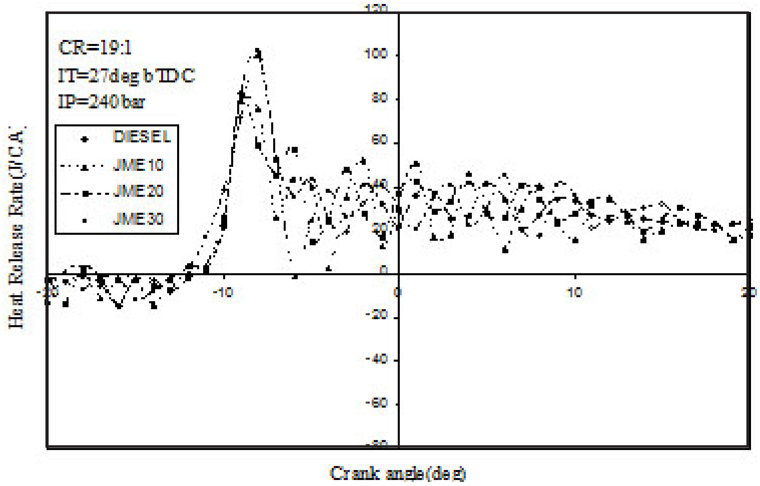


Fig. 9: Variation of Heat release rate with crank angle

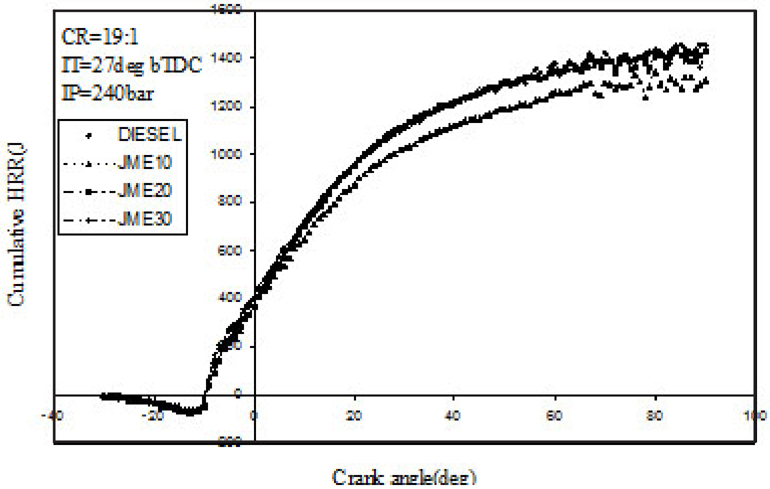


Fig. 10: Variation of Cumulative rate release rate with crank angle

Fig.6.Shows the variation of carbon monoxide emissions of various JME biodiesel blends with brake power. From the figure it is observed the CO emissions of JME are lower than the standard diesel fuel. The reason for the lower CO emission of JME blends are due to the high cetane number of fuel, better combustion, shorter duration of combustion and better spray. Also due to higher compression ratio, injection pressure and injection timing the combustion of the charge occurs in a shorter duration. Hence more heat release occurs and increases the cylinder temperature, as a result the whole mixture are combusted fully without leaving carbon monoxide. In addition the presence of molecular oxygen helps to combust the fuel with less emission.

Fig.7. From the figure it is observed that JME blended fuels offers comparatively higher NOx emission than that of standard diesel. This is mainly due to the presence of high cetane fuel in a blend and higher compression ratio and higher injection pressure. Generally bio-fuel are possessing fewer unsaturation in the molecules.This cause rapid generation of intermediate compounds and consequently the mixture liberates heat in a shorter duration of combustion and hence it offers higher combustion temperatures and promotes the higher NOx formation.

Fig.8.Shows the variation of pressure with crank angle for different jatropha methyl ester biodiesel blends and diesel at full load. The peak pressure of JME20 is slightly higher than that of neat diesel operation. This is the main reason for better thermal efficiency of this fuel than the reference fuel. The presence of high cetane biofuel in a diesel causes better combustion and liberates more heat in a shorter duration. This is the main reason for high peak pressure of this blend JME20.

Fig.9.Shows the variation of heat release rate with crank angle for different jatropha methyl ester biodiesel blends and diesel at full load. It is seen that the height of premixed phase of combustion decreases with addition of JME proportions in the blend. More JME blends offers comparatively lower premixed phase and higher diffusive combustion phase. This is due rapid production of intermediate compounds in high JMEblends.

Fig.10.Shows the variation of cumulative heat release rate with crank angle for different jatropha methyl ester biodiesel blends and diesel at full load.It is noticed that the cumulative heat release rate is decreased for JME20(1432J) compared to diesel(1458J).This is due to higher exhaust gas temperature and NOx emission.

CONCLUSION

Following are the conclusions based on the experimental results obtained while operating single cylinder diesel engine fuelled with biodiesel from Jatropha oil and their blends. Jatropha Methyl esters can be directly used in diesel engine without any modifications.The maximum brake thermal efficiency is found to be JME20 in 27ºbTDC and 240bar at compression ratio 19:1. It is found that the combined increase of compression ratio, injection timing and injection pressure increases the BTHE and reduces BSFC while having lower emissions.Good mixture formation and lower smoke emission are the key factors for good CI engine performance. These factors are highly influenced by viscosity, density, and volatility of the fuel. For bio-diesels, these factors are mainly decided by the effectiveness of the transesterification process. With properties close to diesel fuel, bio-diesel from Jatropha oil can provide a useful substitute for diesel thereby promoting our economy. Finally it can be concluded that JME20 could be used as alternative fuel for operating CI engine at compression ratio of 19:1, higher injector opening pressure of 240bar and advanced injection timing27ºbTDC with less emission of CO and HC and better engine performance.

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