EFFECT OF COMPRESSION RATIO, INJECTION TIMING AND INJECTION PRESSURE ON A DIESEL ENGINE FOR BETTER PERFORMANCE FUELED WITH DIESEL – JATROPHA METHYL ESTER BLEND

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Abstract

In the present investigation, tests were carried out to determine engine performance of a naturally aspirated direct injection diesel engine fueled with diesel and jatropha methyl ester blend (JME20). Comparison of performance was done for different values of compression ratio, injection pressure and injection timing to find best possible combination for operating engine with JME20. It is found that the combined compression ratio of 19:1, injection pressure of 240bar and injection timing of 27$bTDC increases the brake thermal efficiency.From the investigation, it is concluded that the both performance was considerably improved for JME20 compared to diesel.

Keywords: diesel engine, injection timing, injection pressure, jatropha oil methyl esters, performance, emission, combustion characteristics

Notation

BSEC:	brakespecific energy consumption
HRR:	heat release rate
JME20:	blend of biodiesel and diesel having 20% biodiesel and remaining diesel

I. 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 blended 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.

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 °C	48	276	152
Oxygen %w	1.19	11.06	10.97

II. EXPERIMENTAL SET UP

Fig.1 shows the schematic line diagram of the experimental set up and its specification are given in Table 2. An Electrical dynamometer was used to apply the load on the engine. A water rheostat with an adjustable depth of immersion electrode was provided

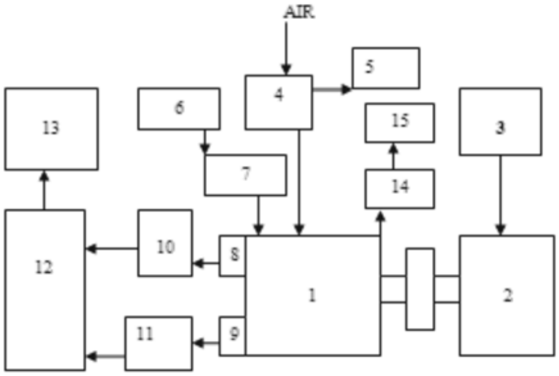

Fig. 1. Experimental set up

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 Delta 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 personal computer. The engine was first operated with diesel oil to generate the baseline data followed by methyl ester jatropha and their blends such as JME20 blend.

Table 2 Specifications of engine

Make	Kirloskar
Model	TAF 1
Type	DI air cooled
Bore ×	Stroke (mm)
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

III. RESULTS AND DISCUSSIONS

Tests were carried out at different compression ratio, injection timing and injection pressure and its details are mentioned in Table 3. At injector opening pressure of 200bar and 220bar and injection timing of 21° bTDC and 24° bTDC and compression ratio of 17.5:1 and 16:1 were tried for JME20 but from the investigation it was found that the performance 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 JME20. It was observed that JME20 it gives better performance for the optimized operating parameters.

Table. 3. Operating parameters considered in the present Investigations.

% Load	0, 25, 50, 75, 1
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

Figure. 2 shows the effect of compression ratio on the variation of brake thermal efficiency with brake power for JME20. The maximum brake thermal efficiency obtained is about 30.9% for JME20 at compression ratio of 19:1.Increase in thermal efficiency is due to the increase in peak pressure and increases in combustion temperature. The other compression ratio

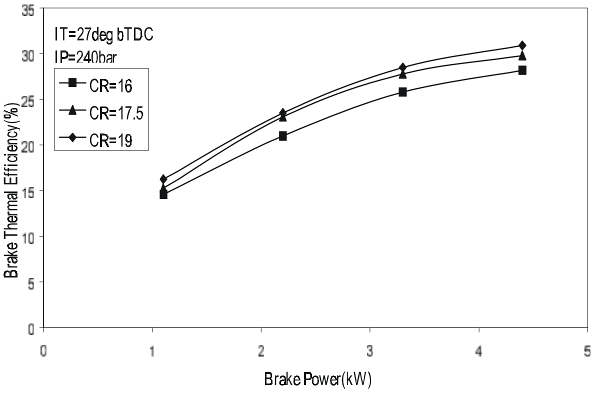

Fig 2. Effect of compression ratio on the variation of brake thermal efficiency with brake power

of 16:1 and 17.5:1 offers relatively lower brake thermal efficiency than that of 19:1.

Figure. 3 shows the effect of injection timing on the variation of brake thermal efficiency with brake power for JME20. It is observed that the increase in injection timing increases the brake thermal efficiency and the maximum brake thermal efficiency occurs at 27° bTDC. The main reason for higher brake thermal efficiency at this particular timing is that the peak pressure occurs closer to TDC also fuel releases all the heat is shorter duration of combustion and resulting in improved performance.

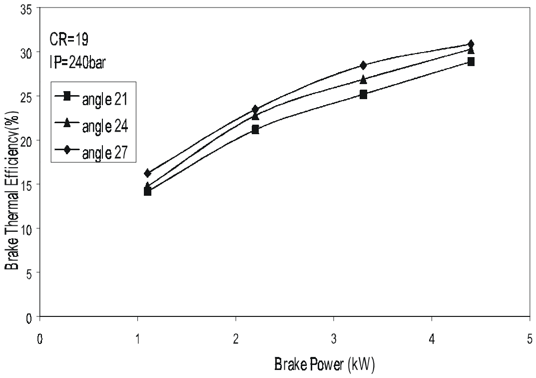

Fig .3. Effect of injection timing on the variation of brake thermal efficiency with brake power

Figure. 4 shows the effect of injection pressure on the variation of brake thermal efficiency with brake power for JME20.It was observed that the increase in brake thermal efficiency with increase in injection pressure may due finer spray and better entrainment.

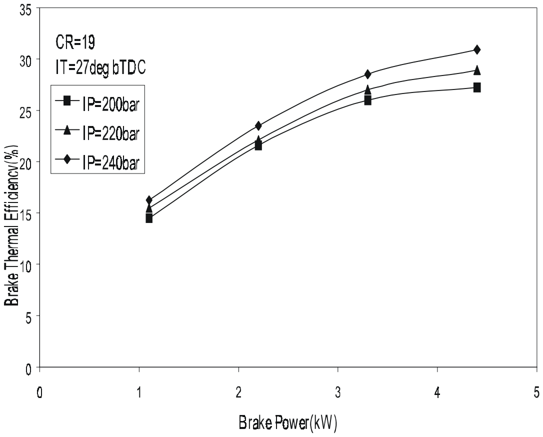

Fig. 4. Effect of injection pressure on the variation of brake thermal efficiency with brake power

Figure. 5 shows the effect of compression ratio on the variation of brake specific energy consumption with brake power for JME20. From the results it is found that JME20 offers comparatively lower BSEC for compression ratio of 19:1 compare to other 16:1 and 17.5:1. This is due to better combustion of JME20 due to presence of high cetane of JME.

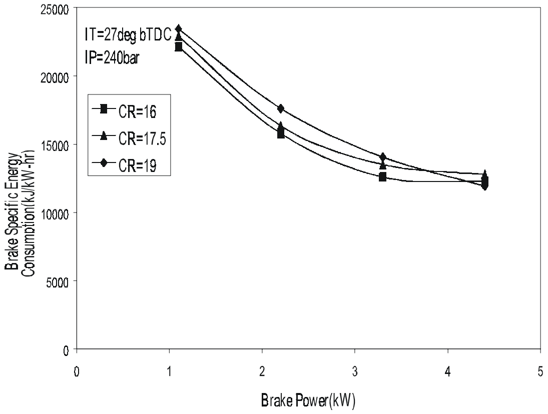

Fig. 5. Effect of compression ratio on the variation of BSEC with brake power

Figure. 6 shows the effect of injection timing on the variation of brake specific energy consumption with brake power for JME20. It is observed that the change in injection timing changes the occurrence of peak pressure and changes the duration of combustion. The injection timing 27° bTDC produces peak pressure closer to TDC and offers sufficient time to release heat, hence this particular timing offers lower BSEC compare to other injection timing 21° bTDC and 24° bTDC.

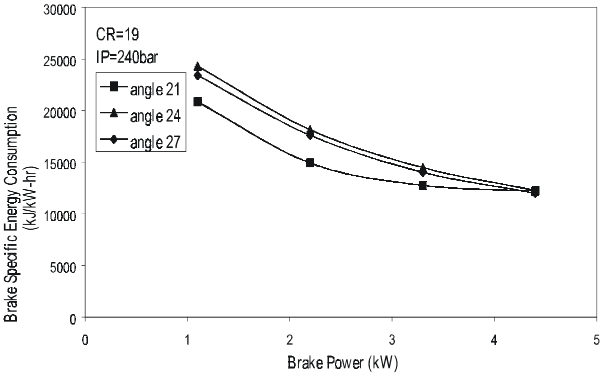

Fig. 6. Effect of injection timing on the variation of BSEC with brake power

Figure. 7 shows the effect of injection pressure on the variation of brake specific energy consumption with brake power for JME20. It was observed that BSEC decreased with increase in injection pressure. The minimum BSEC was observed in JME20 at injection pressure 240bar whereas the maximum BSEC was obtained at injection pressure 200bar. This is due to finer spray, rapid heat release and shorter duration of combustion. Usually, finer spray and improved air entrainment cause lower BSEC for 240bar.

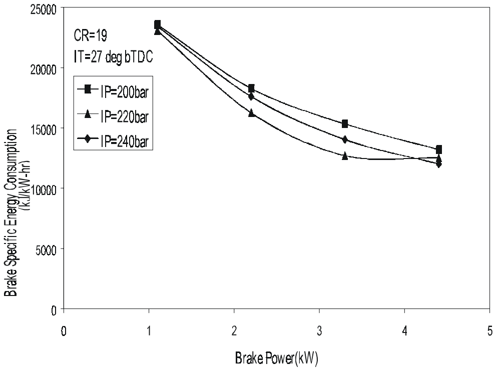

Fig .7. Effect of injection pressure on the variation of BSEC with brake power

Figure. 8 shows the effect of compression ratio on the variation of cylinder pressure with crank angle for JME20. From the results it is clear that peak pressure increases with increase in compression ratio. This is due to increased combustion temperature and shorter duration of combustion.

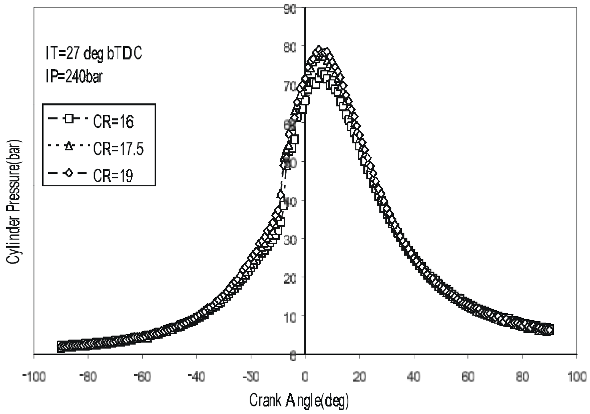

Fig. 8. Effect of compression ratio on the variation of cylinder pressure with crank angle

Figure. 9 shows the effect of injection timing on the variation of cylinder pressure with crank angle for JME20. The change in injection timing changes the occurrence of peak pressure and combustion duration. The injection timing of 27° bTDC produces peak pressure few degree before TDC and utilizes the heat energy well before the completion of power stroke and hence the timing offers maximum peak pressure compare to other timing. This is the main reason for higher brake thermal efficiency of 27° bTDC.

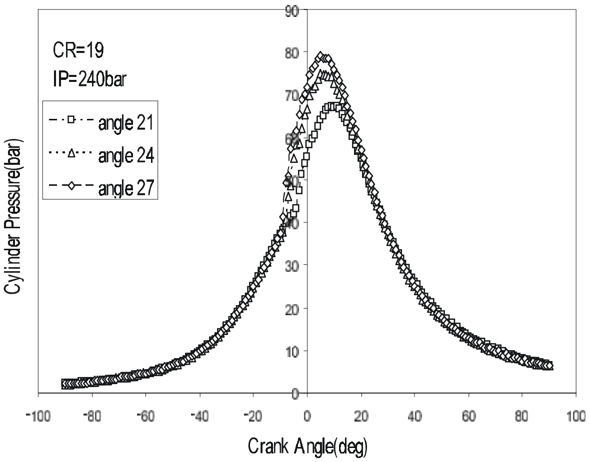

Fig. 9. Effect of injection timing on the variation of cylinder pressure with crank angle

Figure. 10 shows the effect of injection pressure on the variation of cylinder pressure with crank angle for JME20. It was observed that cylinder pressure increases with increase in injection pressure. The change in injection pressure causes change in spray parameters and changes the air entrainment behaviour.The higher injection pressure of 240bar produces finer spray and causes better air entrainment. This is the main reason for higher peak pressure for this injection pressure.

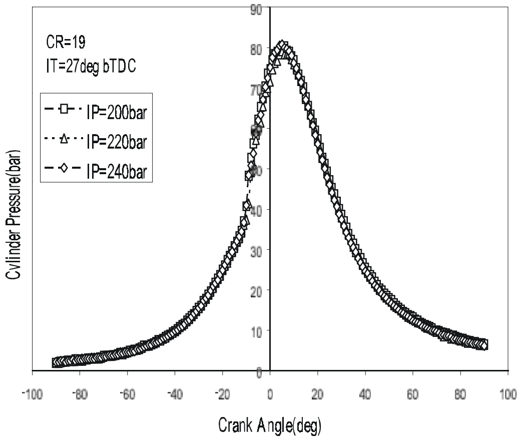

Fig. 10. Effect of injection pressure on the variation of cylinder pressure with crank angle

Figure. 11 shows the effect of compression ratio on the variation of heat release rate with crank angle for JME20. It is seen that the height of premixed phase of combustion decreases with respect to increase in compression ratio. Also the compression ratio increases change the duration of combustion. Usually higher compression ratio offers shorter duration of combustion and cause better performance.

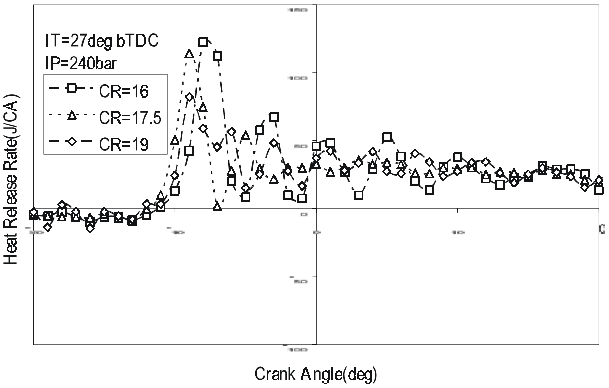

Fig. 11. Effect of compression ratio on the variation of HRR with crank angle

Figure. 12 shows the effect of injection timing on the variation of heat release rate with crank angle for JME20. The injection timing of 27° bTDC offers comparatively shorter duration of combustion and produces peak heat release rate closer to diesel baseline operation.Hence this particular timing offers better performance compared to other injection timing of 21° bTDC and 24° bTDC.

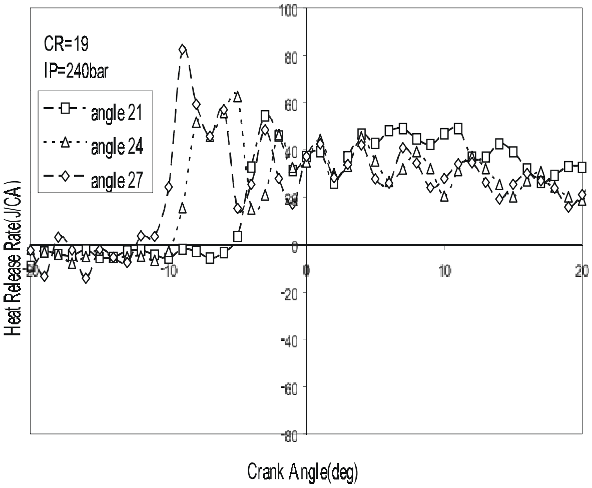

Fig. 12. Effect of injection timing on the variation of HRR with crank angle

Figure. 13 shows the effect of injection pressure on the variation of heat release rate with crank angle for JME20. The injection pressure of 240bar increases spray and mixing property and causes better combustion. Hence it is seen that higher injection pressure offers shorter duration of combustion and rapid rate of heat release than that of other injection pressure of 200bar and 220bar.

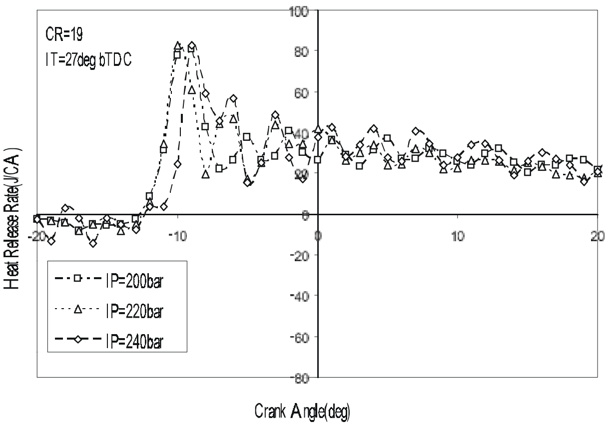

Fig. 13. Effect of injection pressure on the variation of HRR with crank angle

IV. CONCLUSION

Following are the conclusions based on the experimental results obtained while operating single cylinder diesel engine fuelled with JME20.The maximum brake thermal efficiency is found to be JME20 at 27° bTDC, 240bar and compression ratio of 19:1.

It is found that the combined increase of compression ratio, injection timing and injection pressure increases the Brake Thermal Efficiency and reduces Brake Specific Energy Consumption while having lower emissions. Good mixture formation and lower smoke emission are the key factors for good CI engine performance. 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 timing of 27° bTDC for better engine performance.

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