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Effect of Injection Timing and Compression Ratio on Performance, Combustion and Emission Characteristics of a Variable Compression Ratio Engine Fueled with Mango Seed Methyl Ester

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Abstract: In this study, the effect of injection timing and compression ratio on performance, combustion and emission characteristics of a 4- stroke variable compression ratio (VCR) direct injection diesel engine is investigated for different compression ratios (CR) (14,16,18) and injection timings (IT) (21°, 23°, 25° before top dead centre (BTDC)) for mango seed oil methyl ester (MSME) biodiesel blend B20. The brake thermal efficiency (BTHE) is higher (28.86 %) and brake specific fuel consumption (BSFC) is lower (0.3 kg/kWh) at CR18 and IT 21° BTDC. Exhaust gas temperature (EGT) increases with brake power (BP) and showing lower value at higher CR and also at lower IT. The peak cylinder pressure attains at higher CR and advanced injection timing (25° BTDC). Net heat release rate is increasing with decreasing CR. At full load conditions, emissions of carbon monoxide (CO) ,carbon dioxide (CO_2) and hydro carbons (HC) are lower at lower IT and higher CR whereas nitrogen oxides (NO_x) is increasing with CR at all injection timings. The overall good performance and emission results show for CR18 and IT 21° BTDC.

Keywords: mango seed methyl ester, compression ratio, injection timing, performance, emissions, VCR engine.

I. INTRODUCTION

Various sectors like transportation, agriculture and industries are using diesel fuel as a major power source. The usage of automobiles also increases with increasing population, leads to the consumption of higher amount of fossil fuels. In recent years, cost of the petroleum products gradually raises due to the crisis of the petroleum [1-2]. Moreover, pollutants of petroleum products giving trouble to the environment as well as mankind. Diesel engine pollutants like CO, CO_2, HC causes the formation of acid rains, depletion of the ozone layer and visibility reduction. According to the health expert reports, the pollutants such as sulfates and particulate matter are also considered as toxic air pollutants which are responsible for various diseases like emphysema, asthma, bronchitis etc [3]. Hence, it is necessary to develop the alternative energy sources. Recently, researchers are focusing on alternative renewable sources such as biodiesel produces from straight vegetable oils, animal fats, and waste oils. Biodiesel has made significant contribution to meet the demand and environmental problems. Biodiesel can be used in the diesel engines as pure form [7] or with different ratio of blends [12] without any modification of engines. Diesel engine pollutants can be reduced by using biodiesel, which consist of a combination of diesel, biodiesel and ethanol [5]. Furthermore, metal-based nano-catalysts can be used to reduce pollutants. Various modifications in engines such as exhaust gas recirculation (EGR), diesel oxidation catalyst (DOC), elective catalytic reduction (SCR) and diesel particulate filter (DPF) system have developed to minimize the pollutants. By varying various engine parameters like fuel injection timing[18,24], injection pressure,[6] compression ratio(VCR),[13-21] etc. and application of several techniques such as turbo charger, preheating, low heat rejection (LHR), and homogeneous charge compression ignition (HCCI) concept, etc[4,10,11], the performance, combustion, and emission characteristics of engines may be improved. Many researchers used different biodiesels like mahua, karanja, canola, soyabeen oil methyl esters etc,[2,6,12] and got good results at B20 blend [2,3,8,11]. Some of the additives like alcoholic additives (solketal and ethanol) and antioxidant additives such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), tert-butylhydroquinone (TBHQ) and 2-ethylhexyl nitrate (EHN) [5,8,9] are used for reduction of emissions. In present study, B20 blend of mango seed oil methyl ester is used to investigate the effect of compression ratio and injection timing on performance, combustion and emission characteristics of a four stroke variable compression ratio (VCR) direct injection diesel engine for different compression ratios (CR) (14,16,18) and injection timings (IT) (21°, 23°, 25° before top dead centre (BTDC)).

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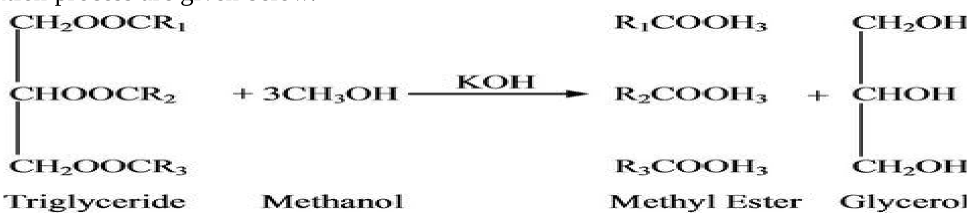
II. MATERIALS AND METHODS

In this study, commercial diesel was brought from local petroleum station, mango seed oil was brought from oil mills and biodiesel was produced via transesterification process. Initially, mango seed oil was reacted with a monohydric alcohol (methanol (CH3OH)) in the presence of catalyst (potassium hydroxide (KOH)). The process of transesterification was affected by the mode of reaction condition, molar ratio of alcohol to oil, type of alcohol, type and amount of catalysts, reaction time, temperature and purity of reactants. After transesterification, water wash was carried out by distilled water followed by heating for purity. The different steps involved in transesterification process are given below.



The physical and thermal properties of the Diesel fuel and biodiesel blend B20% are summarized in Table 1. The representative values like fire point, density, flash point, viscosity, cetane index and gross calorific value are measured for biodiesel and its blends

TABLE 1
Fuel properties of diesel and biodiesel blends

Properties	Diesel (D100)	B20	Biodiesel (B100)
Flash point in ^{0} C	60	78	160
Fire point in ^{0} C	63	82	170
Density kg/m^3	830	849	929
Kinematic viscosity in cst at 40^{0}C	3.26	3.51	4.66
Calorific value in kJ/kg	42500	41888	39442
Cetane number	51	----	48

III. EXPERIMENTAL SETUP

A 5HP (3.5 kW) variable compression ratio 4-Stroke direct injection Diesel engine was chosen with compression ratios varying from 14 to 18 (shown in Fig.1). The air flow rate into the engine was measured by mass flow sensor and the fuel consumption was measured by burette method. Loading was applied on the engine with the help of eddy current dynamometer. The experiment was carried out at different compression ratios (14, 16, and 18) and injection timings (21^0,23^0, and 25^0 BTDC) at different loads (0, 25, 50, 75% and full load). Various sensors were utilized during the experiment to collect, store and analyze the data by computerized data acquisition system(IC engine soft). An exhaust gas analyzer (AIRREX HG-540, 4 Gas analyzer) was employed to measure HC, CO, CO_2 and NO_X emissions. The performance, combustion and emission results obtained were tabulated. The specifications of VCR engine are shown in Table 2.

TABLE 2
Specifications of the variable compression ratio engine

Engine parameters	Specifications
Make	Kirloskar
Model/Type	TV1/Four stroke
Number of cylinders	Single
Bore/Stroke	87.5 mm/110 mm
Rated power	5 HP(3.5 kW) @ 1500 rpm
Capacity(cc)	661
Type of cooling	Water cooled
Compression Ratio range	12–18

Injection timing range	0- 25^0 BTDC
Loading	Eddy current dynamometer
Data acquisition device	NI USB-6210, 16-bit, 250kS/s.
Temperature sensors	Type RTD, PT100 and Thermocouple, K-Type
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Fuel flow transmitter	DP transmitter, Range 0-500 mm WC
Air flow transmitter	Pressure transmitter, Range (-) 250 mm WC
Software	“Engine soft” Engine performance analysis software
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH

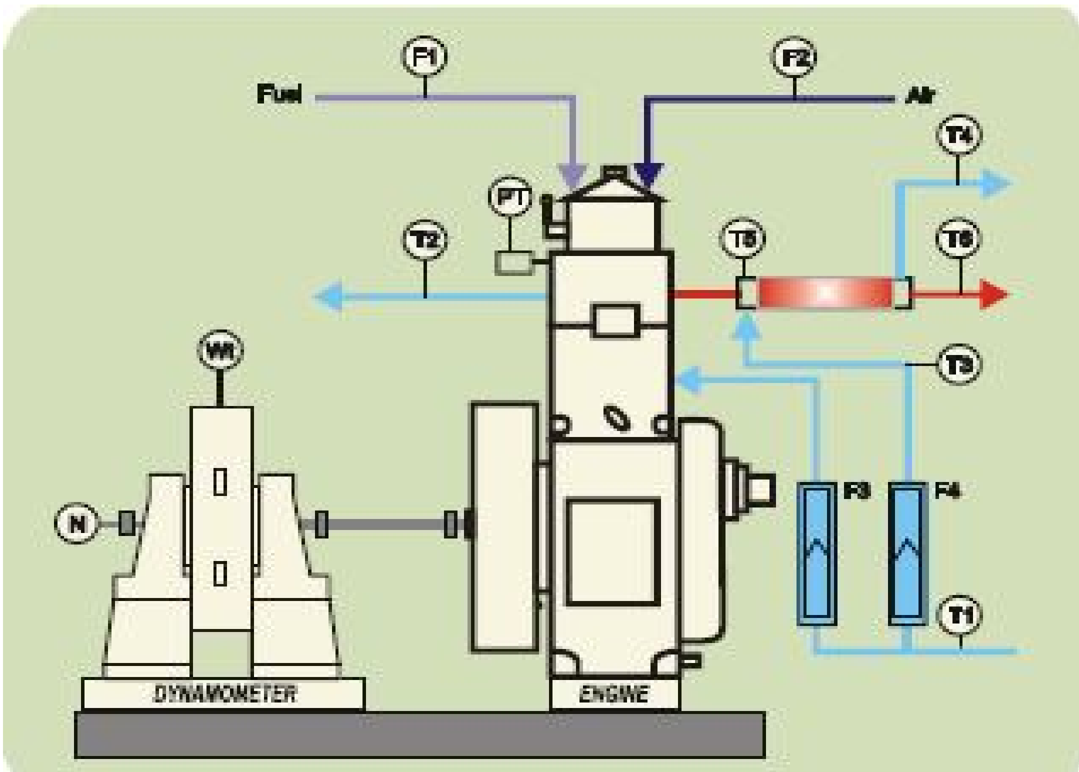


Fig.1 Experimental setup

IV. RESULTS AND DISCUSSIONS

A. Performance Characteristics

The major performance parameters such as Brake power (BP), Brake thermal efficiency (BTHE), BSFC, exhaust gas temperature are evaluated for B20 of MSME.

1) Brake power and Brake thermal efficiency: Fig. 2a shows the variation of BTHE with BP for different compression ratios (14, 16, 18) and injection timings (21^0, 23^0, 25^0 BTDC). BTHE is linearly increasing with BP and CR. Among all compression ratio and injection timing, CR18 IT 21^0 BTDC (In the Fig. 2c) exhibited higher brake thermal efficiency (28.86%) at full load condition while at standard injection timing (23^0 BTDC) is 28.65%. Retarding injection timing increases the BTHE for biodiesel may be due to fast start and complete combustion of biodiesel blend B20 [23].

2) Brake power and Brake specific fuel consumption: The variation of BSFC with BP for different compression ratios is shown in Fig.2b. It is observed that the BSFC reduces while increasing BP and load at different compression ratios. At full load conditions, brake specific fuel consumption is low for compression ratio 18 but it is reducing with injection timing (Fig. 2d), in which injection time 21^0 BTDC shows slightly lower than other.

3) Brake power and exhaust gas temperature: Fig.3a compares the exhaust gas temperature of blend B20 for different compression ratio and injection timing. It can be observed that the exhaust gas temperature increases linearly with brake power, but CR 18 shows slightly lower values. Fig.3b shows the variation of exhaust gas temperature with injection timing for different compression ratio at full load. It is clearly shows that the temperature decreases when compression ratio increases. The lower EGT value (221^0 C) exhibited at 21^0 BTDC for CR18 whereas it is 233 and 229 for CR14 and CR16, respectively. The lower value for CR18 may be due to the complete combustion of the fuel and reduced the heat loss during the combustion.

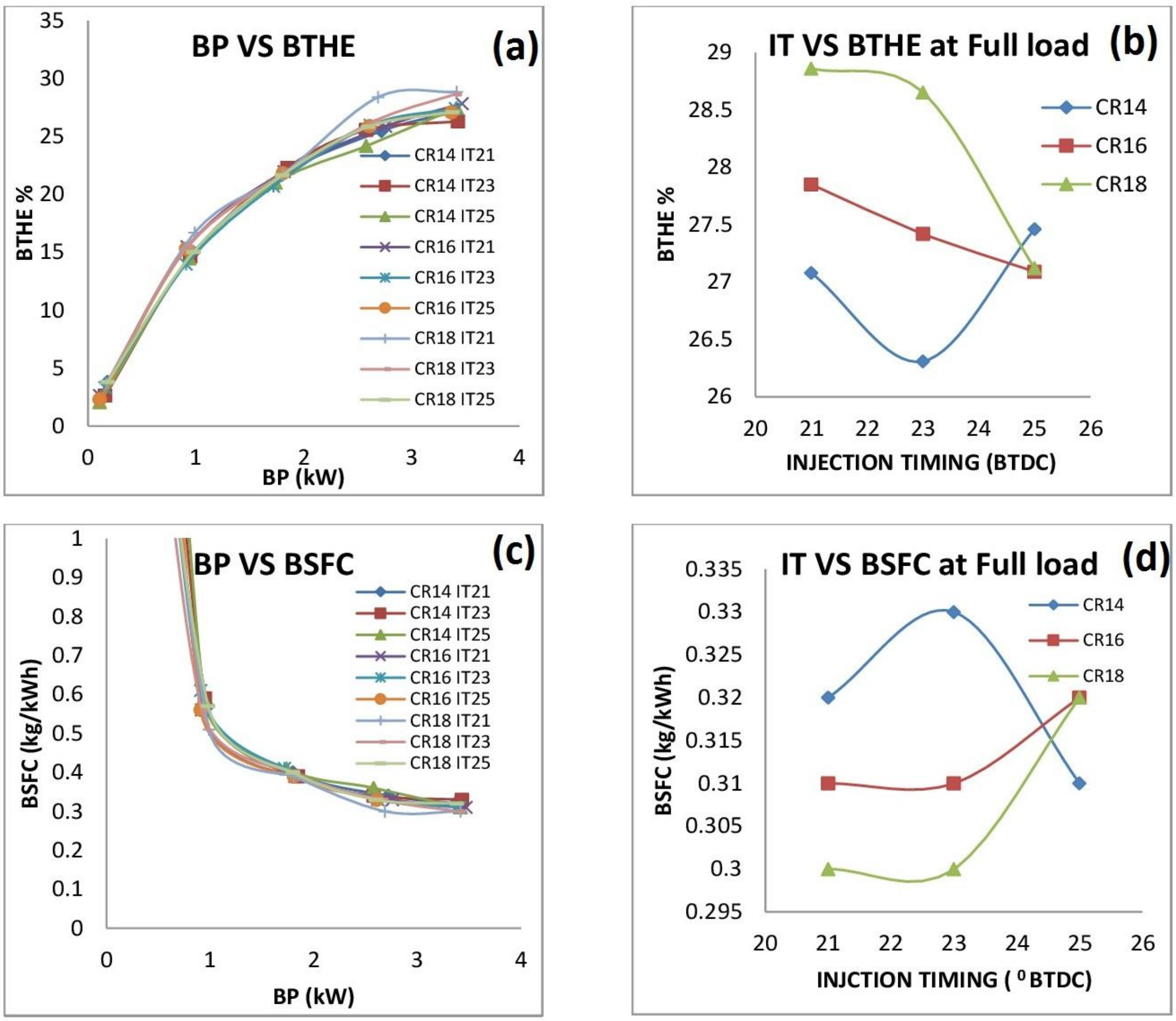


Fig.2 Variation of BTHE and BSFC with BP (a, c) and IT (b, d) for different compression ratios

B. Combustion Characteristics

The major parameters that influence the combustion inside the cylinder are ignition delay, cylinder pressure, heat release rate and mass of fuel burned.

1) Cylinder pressure (CP): Variation of cylinder pressure with crank angle for different compression ratio and injection timing is shown in the Fig. 4a. Cylinder pressure is increasing with CR and IT. The peak pressures attained for CR18 IT 21^0 BTDC, CR18 IT 23^0 BTDC, and CR18 IT 25^0 BTDC are 74.86, 76.28, and 77.44 bar, respectively. This may be uncontrolled combustion due to ignition delay. Ignition delay increases when injection timing increases and also an increase in time for pre mixed combustion [23].

2) Net heat release rate (NHRR): Fig.4b shows the variation of net heat release rate with crank angle for different CR and IT. The HRR is analyzed based on the changes in crank angle variation of cylinder and it is increased with lower CR and slightly deceased at higher CR. It is observed that CR18 IT 21^0 BTDC shows lower HRR. The peak values for all combinations of CR and IT shows along 15^0 span.

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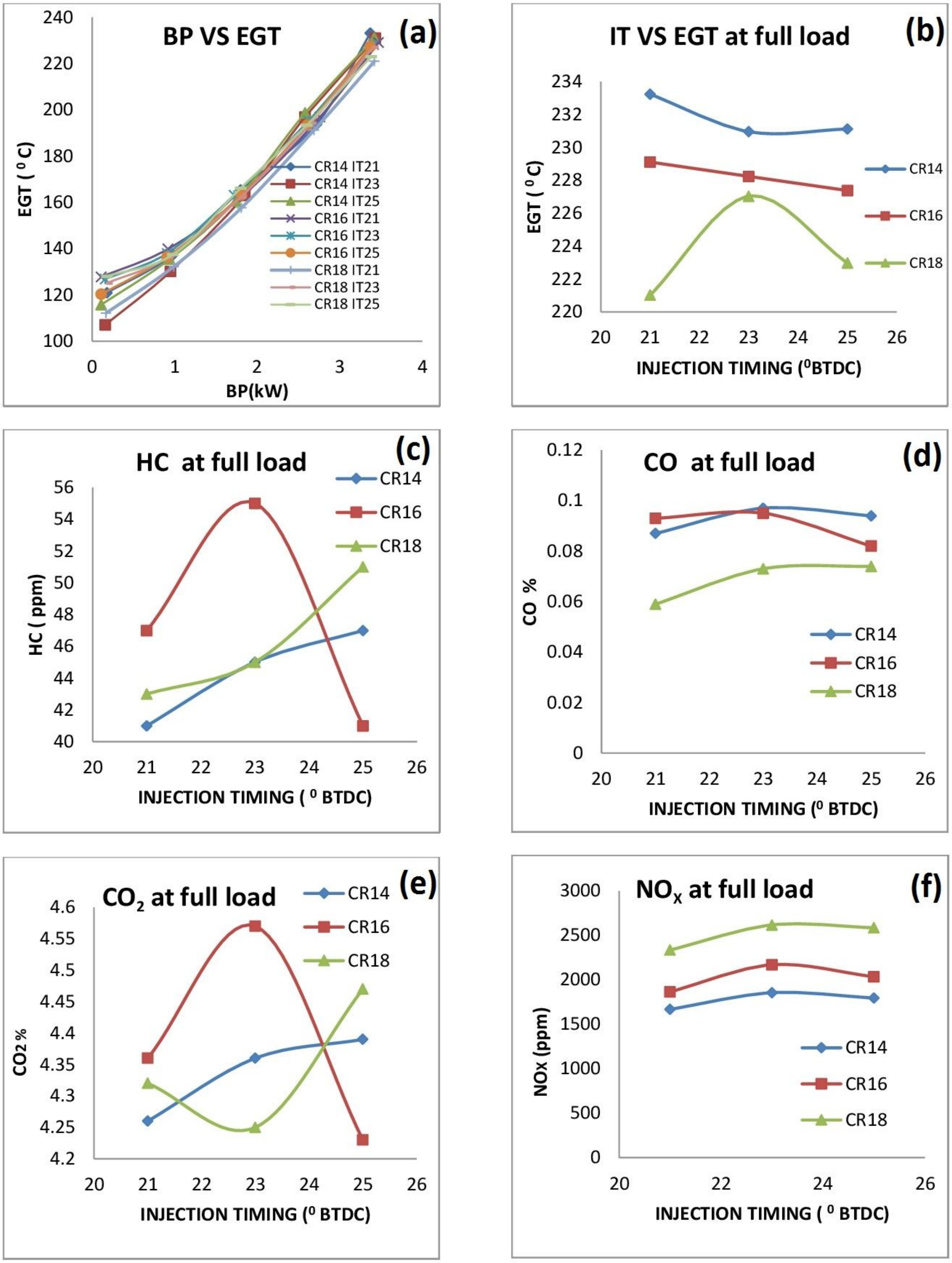


Fig.3 Variation of EGT with BP and IT for different compression ratios (a,b), variation of HC, CO, CO_2 and NO_x with IT for different compression ratios (c-f)

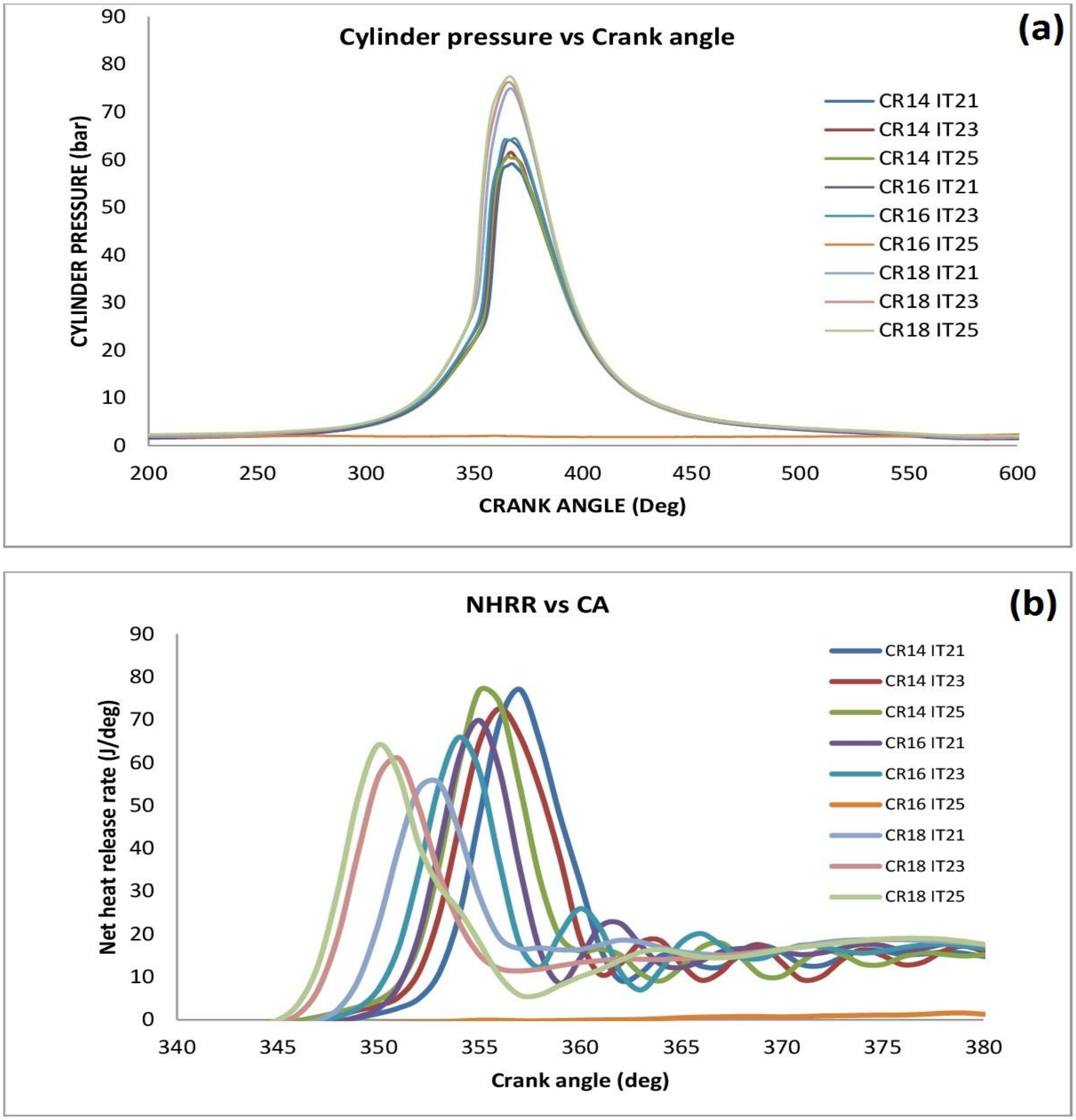


Fig.4 Variation of CP and NHHR with crack angle (a, b)

C) Emission Characteristics: The major contributions of air pollution are unburned hydro carbons (HC), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x) and particulate matter from internal combustion engines. The effects of CR and IT on emissions of B20 blend of MSME are discussed here.

1) Hydro carbons (HC): Fig. 3c shows the variation of hydro carbon emissions with injection timing for different compression ratio at full load condition. At CR14 and CR18, HC increase with IT but lower HC emission recorded at IT 21^0 BTDC (41,43ppm). Whereas CR16 increases to maximum value (55 ppm) at IT 23^0 BTDC then it is decreases to lower value (41ppm) at (25^0 BTDC).

2) Carbon monoxide (CO): CO production is mainly depends on air-fuel ratio and combustion efficiency. The emissions of carbon monoxides shows lower value at all injection timing for CR18 but it's minimum value at IT 21^0 BTDC as shown in Fig.3d. However, it is slightly higher value For CR14 and CR16.

3) Carbon dioxide (CO_2): Fig.3e shows the emissions of CO_2 for different injection timings and compression ratios at full load. CR14 curve rises with IT where as CR16 and CR18 curves vary opposite direction. It is observed that the CR18 curve shows minimum emission at IT 23^0 BTDC, whereas it is maximum for CR16.

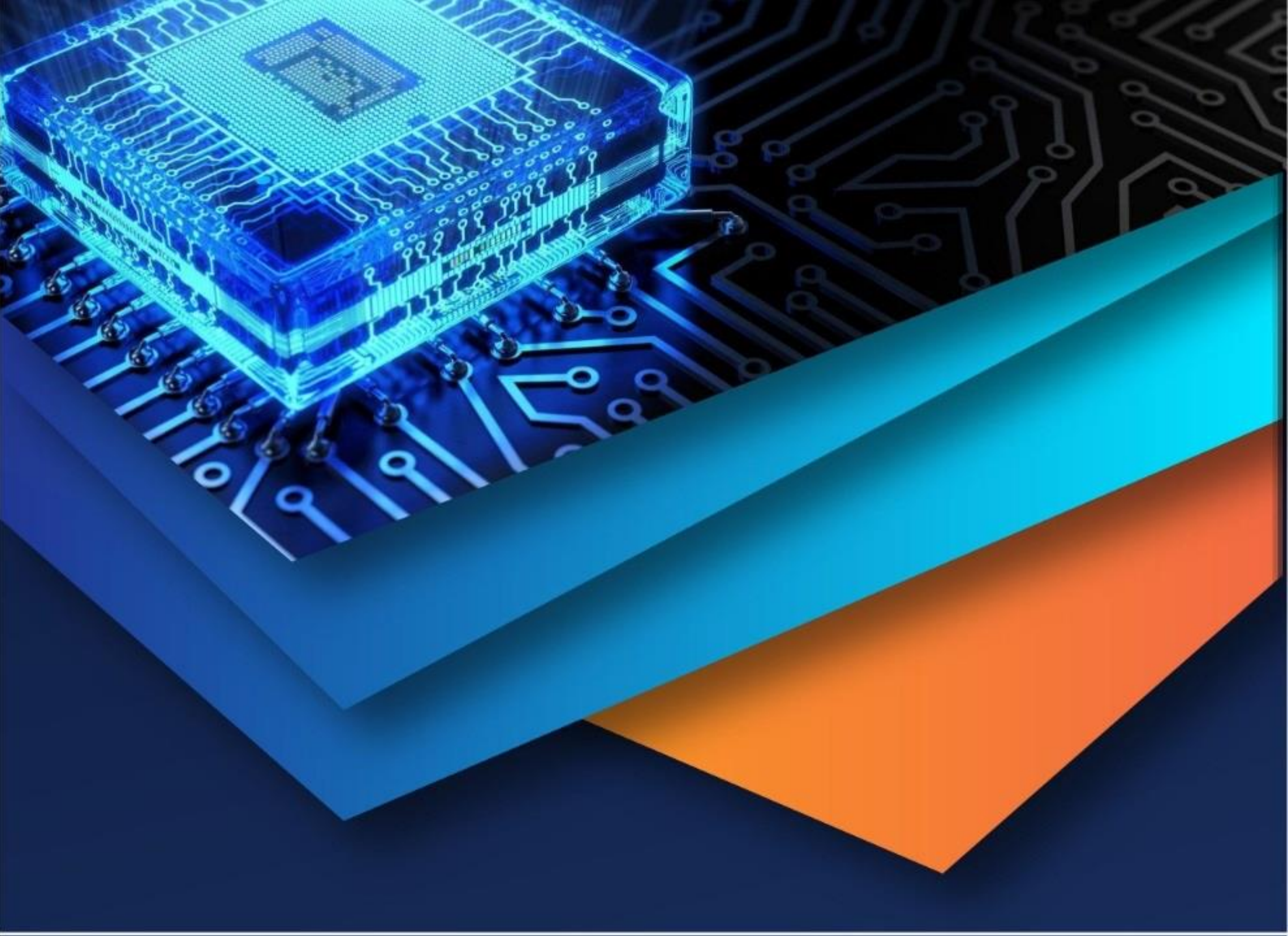
4 Nitrogen oxides (NOx): Fig.3f shows the variation of NO_x emissions with injection time for different compression ratios at full load condition. NO_x is always higher for CR18 because of maximum power and higher temperatures inside the cylinder at full load conditions when compare to CR14, CR16.

V. CONCLUSION

The effect of compression ratio and injection timing on performance, combustion and emission characteristics of a four stroke VCR direct injection diesel engine is investigated for various compression ratios and injection timings for mango seed oil methyl ester (MSME) biodiesel blend B20. CR18 IT 21^0 BTDC exhibited higher brake thermal efficiency (28.86%) at full load condition. BSFC exhibited lower values at higher compression ratio. The peak pressures attained for higher compression ratio and injection time. The significant reduction was observed in the HC, CO and CO_2 emission. Mango seed oil is lower when compared to conventional diesel. The addition of 20% of mango seed oil methyl ester with 80% diesel will meet certain extent to the shortage of availability of diesel.

REFERENCES

[1] M. Shahabuddin, A. M. Liaquat, H. H. Masjuki, M. A. Kalam, and M. Mofijur, “Ignition delay , combustion and emission characteristics of diesel engine fueled with biodiesel,” Renew. Sustain. Energy Rev., vol. 21, pp. 623–632, 2013.
[2] M. F. Al-dawody and S. K. Bhatti, “Optimization strategies to reduce the biodiesel NOx effect in diesel engine with experimental verification,” Energy Convers. Manag., vol. 68, pp. 96–104, 2013.
[3] E. B. F. Blends, “Academic @ Paper,” 2016.
[4] A. K. Azad, M. G. Rasul, M. M. K. Khan, S. C. Sharma, and M. M. K. Bhuiya, “Recent development of biodiesel combustion strategies and modelling for compression ignition engines,” Renew. Sustain. Energy Rev., vol. 56, pp. 1068–1086, 2016.
[5] S. Hoseini, G. Naja, B. Ghobadian, R. Mamat, N. Azwadi, C. Sidik, and W. H. Azmi, “The e ff ect of combustion management on diesel engine emissions fueled with biodiesel-diesel blends,” vol. 73, no. January, pp. 307–331, 2017.
[6] A. Syed, S. Azam, P. Quadri, G. A. P. Rao, and M. Wajid, “Experimental investigations on DI (Direct injection) diesel engine operated on dual fuel mode with hydrogen and Mahua oil methyl ester (MOME) as injected fuels and effects of injection opening pressure,” Appl. Therm. Eng., 2016.
[7] D. N. Tziourtzioumis and A. M. Stamatelos, “Experimental Investigation of the Effect of Biodiesel Blends on a DI Diesel Engine ’ s Injection,” 2017.
[8] E. Ileri, “Experimental investigation of the effect of antioxidant additives on NO x emissions of a diesel engine using biodiesel,” vol. 125, no. x, pp. 44–49, 2014.
[9] E. Alptekin, “Emission , injection and combustion characteristics of biodiesel and oxygenated fuel blends in a common rail diesel engine,” Energy, vol. 119, pp. 44–52, 2017.
[10]T. M. Yunus, I. Anjum, A. Badarudin, N. R. Banapurmath, N. J. S. Ahmed, G. A. Quadir, A. A. A. A. Al-rashed, and H. M. T. Khaleed, “Effects of engine variables and heat transfer on the performance of biodiesel fueled IC engines,” Renew. Sustain. Energy Rev., vol. 44, pp. 682–691, 2015.
[11]S. Lahane and K. A. Subramanian, “Effect of different percentages of biodiesel – diesel blends on injection , spray , combustion , performance , and emission characteristics of a diesel engine,” FUEL, vol. 139, pp. 537–545, 2015.
[12]A. Kumar and K. A. Subramanian, “Control of Greenhouse Gas Emissions (CO2, CH4 and N2O) of a Biodiesel (B100) Fueled Automotive Diesel Engine using Increased Compression Ratio,” Appl. Therm. Eng., 2017.
[13]B. Naik and K. Radha, “Performance and Emission of VCR-CI Engine with palm kernel and eucalyptus blends ☆,” Perspect. Sci., vol. 8, pp. 195–197, 2016.
[14]M. Krishnamoorthi and R. Malayalamurthi, “Experimental investigation on performance, emission behavior and exergy analysis of a variable compression ratio engine fueled with diesel- aegle marmelos oil - diethyl ether blends,” Energy, 2017.
[15]K. Sivaramakrishnan, “Investigation on performance and emission characteristics of a variable compression multi fuel engine fuelled with Karanja biodiesel – diesel blend,” Egypt. J. Pet., pp. 1–10, 2017.
[16]Emission Characteristics of Variable Compression Ratio Engine Fueled with Preheated Palm Oil - Diesel Blends,” vol. 11\
[17]V. Hariram and R. V. Shangar, “Influence of compression ratio on combustion and performance characteristics of direct injection compression ignition engine,” Alexandria Eng. J., vol. 54, no. 4, pp. 807–814, 2015.
[18]B. J. Bora and U. K. Saha, “Optimization of Injection Timing and Compression Ratio of a Raw Biogas Powered Dual Fuel Diesel Engine,” Appl. Therm. Eng., 2015.
[19]B. J. Bora and U. K. Saha, “Experimental evaluation of a rice bran biodiesel e biogas run dual fuel diesel engine at varying compression ratios,” Renew. Energy, vol. 87, pp. 782–790, 2016.
[20]R. Thomas, M. Sreesankaran, J. Jaidi, D. M. Paul, and P. Manjunath, “Experimental evaluation of the effect of compression ratio on performance and emission of SI engine fuelled with gasoline and n-butanol blend at different loads ☆,” Perspect. Sci., vol. 8, pp. 743–746, 2016.
[21]S. V Channapattana, C. Kantharaj, V. S. Shinde, A. A. Pawar, and P. G. Kamble, “Emissions and Performance Evaluation of DI CI - VCR Engine Fuelled with Honne oil Methyl Ester / Diesel Blends,” Energy Procedia, vol. 74, pp. 281–288, 2015.
[22]M. Gumus, “A comprehensive experimental investigation of combustion and heat release characteristics of a biodiesel (hazelnut kernel oil methyl ester) fueled direct injection compression ignition engine,” Fuel, vol. 89, no. 10, pp. 2802–2814, 2010.
[23]S. Bari, “Performance , combustion and emission tests of a metro-bus running on biodiesel-ULSD blended (B20) fuel,” Appl. Energy, vol. 124, pp. 35–43, 2014.
[24]M. Mani and G. Nagarajan, “Influence of injection timing on performance , emission and combustion characteristics of a DI diesel engine running on waste plastic oil,” Energy, vol. 34, no. 10, pp. 1617–1623, 2009.



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