International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8, Issue-1, May 2019

Experimental Investigation of Performance, Emissions and Combustion on 4 Stroke Single Cylinder Direct Injection Compression Ignition (Dici) Engine using Diesel Blends

S Suyambazhahan

***Abstract:** The engine was tested with biodiesel blends for various loads and the speed is maintained constant at 1500 rpm to study the improvement of performance. Experimental result shows that brake thermal efficiency (BTE) increased upto14.7%, brake specific fuel consumption (BSFC) decreased up to 8.7%. The exhaust gas temperature 131^{0}C (pure diesel) reduced to 112 ^{0}C at zero break power, whereas exhaust gas temperature increased from 548 ^{0}C to 571 ^{0}C at maximum load due to faster burning of blended fuels. The mean effective pressure (MNEP) at different break power with an engine speed of 1500 rpm found as 74.9 bar for blends and 68.8 bar for pure diesel. Heat release rate found 162.1 KJ/m^{3}K for D50 E40 blend and 121.2 KJ/m^{3}K for pure diesel at maximum break power. Longer ignition delay and shorter combustion duration are found with all blends than pure Diesel fuel. The concentrations of NOx, CO, CO2, PM and HC gases reduced to 0.036% in exhaust emission for biodiesel blends. Also, the smoke density is drastically reduced to 36 [HSU-Hartridge smoke units] than that of Diesel fuel. The oxygen concentration, fuel distribution, latent heat of vaporization, combustion temperature, ignition delay and cetane number have improved performance, combustion and reduced exhaust gas emissions. This study has been used for the applications in automotive engines.*

***Keywords:** Biodiesel Blends, DICI Engines, BSFC, BTE, EGT, MNEP, Combustion and Exhaust Emissions (EE)*

I. INTRODUCTION

The Diesel engines are classified into two types as direct injection engines and Indirect injection engines according to the fuel injection methods. The direct injection compression ignition engines are more efficient and cleaner so it is more advantages for automotive application. Diesel atomizers are mounted at the top of the cylinder combustion chamber and operated by hydraulic pressure method. Since the diesel is directly injected into the combustion chamber 15-20% of diesel is saved for the same performance than indirect fuel injection method.

Revised Manuscript Received on 30 May 2019.

***** Correspondence Author
S Suyambazhahan*, Department of Mechanical Engineering, Dhanalakshmi College of Engineering, Anna University Chennai, India

A detailed literature review has been carried out in the field of biodiesel fuelled engines as follows Arkadiusz Jamrozik [1] has performed a study on CI engine [single cylinder] using diesel-methanol and diesel-ethanol blends experimentally.

The 30% of methanol and 40% alcohol by volume was added with diesel for the improvement of thermal efficiency. The results reveal that the Engine efficiency increased, carbon monoxide emissions are reduced and significant changes found in hydrocarbons and carbon dioxide emissions but no significant changes in indicated mean effective pressure. Further increase in methanol of over 30% caused disturbances and further addition of alcohol had a negative effect on nitrogen oxides emissions. Sathiyamoorthi and Sankaranarayanan [2] have been examined the outcome of the concentration of ethanol on efficiency, emissions and combustion and DICI engine using ethanol (2.5% and 5%) and lemongrass oil (LGO) diesel blend experimentally. The result shows better performance, combustion, emission, higher delay of ignition period and duration of combustion of ethanol blends than neat diesel. Das et al [3] have been performed the study on CI Engine using biodiesel Castor Oil Methyl Ester (COME) to improve combustion, performance and emission features. The surface tension and viscosity of fuel blends with temperature variation are determined experimentally. The COME has lower evaporation rate than diesel so biodiesel blends start combustion earlier than diesel. During combustion, for the blended fuels, the pressure rise is faster than diesel and no significant changes in performance and emission. Fu et al [4] have been studied the CI engine for performance, emission and combustion features by using corn bio-oil diesel emulsions (CBDEs) with nano additive (Ce0.7Zr0.3O2). A lower specific fuel consumption was achieved with the CBDE fuels at medium and high powers compared to diesel. The complete combustion was obtained due to the addition of nanoparticles. The CBDEs with lower bio-oil proportion [less than 20%] decreased CO, HC and smoke emission, however, increasing bio-oil proportion led to a reduction of emission of NOx for blends than diesel.

Osman and Mehmet [5] have been investigated performance, combustion and emission of exhaust features of CI engine with alcohol blends [B10, E10, and M10] in diesel and D100 (petroleum-based diesel fuel). Since alcohol fuels have low cetane number, the more ignition delay occurs than D100 diesel fuel. D100 has highest thermal efficiency and lowest fuel consumption due to higher heating value for all engine loads compared to alcohol blends.

The nitrogen oxides (NOx) emissions slightly increased while reducing carbon monoxide (CO) and smoke emissions.

Nadeem et al [6] have been reported from the study that the emulsification [Water/diesel (W/D) emulsified] is a possibly effective technique to reduce SOx, NOx, CO and PM in emissions. The results indicate that SOx, NOx, CO, and PM are greatly reduced in emission due to Gemini surfactant with the incorporation of 15% of water contents in diesel which reduces the environmental hazards.

Prakash et al [7] have been performed study on combustion, emission, and efficiency of a CI engine experimentally using diesel with Neat Castor Oil (NCO) blends. The results show that an optimum volume ratio of NCO-diesel bioethanol for best performance and emission than diesel is NCO40 + E30 + D30. Ghazali et al [8] have been evaluated torque, brake power, BTE, EGT, BSFC and emissions of NOx, CO, CO2, PM, HC and smoke density with biodiesel. The study concluded that the biodiesel has good improvement of performance and emissions than diesel fuel for the energy demand globally. Prabakaran and Anurag [9] have been investigated the effects of zinc oxide nanoparticle [250 ppm] on performance, combustion and emission features of ethanol blends in CI Engine at 1500 rpm. There are six blends were tested out of which one blend was used to test the engine. The results indicate that the calorific value and performance were increased and also there was a decrease in BTE, NOx, and smoke than diesel. Jamuwa et al [10] have been investigated burning features, thermal efficiency and exhaust gas emissions in diesel engine [small capacity] using sterilized ethanol experimentally. The results show that due to deteriorated combustion, the brake thermal efficiency decreased up to 11.2% at break power, however, efficiency increased up to 6% at higher brake power because of improved combustion than pure diesel. Similarly, the exhaust emissions of NOx 22%, smoke 41% and CO2 27% reduced with a concurrent increase in HC 144% and CO 139% for dissimilar rates of ethanol decontamination than pure diesel.Lee et al [11] were investigated the engine performance and emissions with variable ethanol substitution ratio and dual-fuel combustion under fixed rpm [1000] at various load conditions experimentally. The result shows that PM emissions and NOx decreased with the increase of the mean size of the PM emissions and ethanol substitution but, higher ethanol fractions could not be used for low and high loads because at low loads ignition energy of deficient. Srinivasa Rao and Anand [12] were investigated the performance of a DICI engine using Aluminum oxide hydroxide (AlO(OH)) nanoparticles (25, 50 and100 ppm) as additive biodiesel emulsion fuels. The results exposed that the performance was lower, and NO level greater for the biodiesel compared to diesel. However, emissions and performance features were increased by the inclusion of Aluminum oxide hydroxide.

Sharanappa et al [13] have been performed combustion tests in a DI diesel engine [kirloskar H394] with methyl ester, fish oil blends at speed of 1500 rpm with adjustable load settings. The test result shows that better environment due to good combustion properties and but the engine performance and reduction of NOx emissions was not much improvement.

Palash et al [14] have been studied some technologies to reduce NOx emissions by using additives, EGR [exhaust gas recirculation] 4–45%, WI [water injection] 26–84%, ET [emulsion technology] 10–38%, ITR [injection timing retardation] 9.77–37%, ST [simultaneous technology] 22–95% and LTC [low temperature combustion] 66–93%. However, the average reduction of NOx emissions for each technology is 36–46%, 3–34%, 21–37%, 33–92% and 8.68–70% which are reasonable than diesel. From the results, it is identified that the new technology LTC is more efficient to reduce emissions of NOx and PM. Swaminathan and Sarangan [15] have been performed studies on exhaust emission and performance features in diesel engine [single cylinder] and generator set using Bio-Fish Oil with Diethyl ether [DEE] as a substitute for diesel. The performance has been improved by oxygenate process and to reduce the emission of engine exhaust, gas recirculation (EGR) technique was used. The results show that at minimum load, the percentage of emission reduced to NOx-92%, CO-91%, CO2-62% and CxHy-90%. For 2% of additive, the optimum values were attained however, the emissions were increased when the percentage of additive is increased or decreased than 2%. Shahir et al [16] have been carried out a review study on a diesel engine for emissions and performance features with bioethanol blend. The diesel–biodiesel–ethanol/bioethanol blend needs additives to avoid stability problem for engine performance and physicochemical properties. The ternary blends considerably reduce the emissions of PM but depend on operating conditions, soot emissions, smoke, NOx (nitrogen oxides), CO, CO2, HC (hydrocarbon) and carbonyl compounds. Asokan et al [17] have been performed studies on CI engine [single cylinder 4-stroke] for performance, combustion and emission features with watermelon and papaya bio-diesel blend produced by transesterification process with methanol and KOH (catalyst). The tests were conducted for different blends such as B0, B20, B30, B40, B100, WP [50% watermelon + 50% papaya blend by volume] and watermelon 100% and papaya 100% with diesel. The result reveals that the blend B20 have greater emission features and it reduces diesel consumption by 20% than other biodiesel blends. Ghojel et al [18] have been performed the studies on performance and emission features on diesel engine working with diesel oil blend. The emissions of NOx and PM are reducing by using blends of diesel and water. The measurements of performance and emissions of NOx, hydrocarbon were completed during the test. The result shows that the BSFC increases due to use of emulsion, retarded fuel injection, smaller ignition delay due to this cylinder pressures and lower the values of temperatures.

International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8, Issue-1, May 2019

Mikulski et al [19] performed the studies on emissions and performance of Common Rail Direct Injection [CRDI] CI Engine using blends with swine lard methyl esters produced from alkali transesterification process and optimized biofuel combustion using mineral diesel mixture. The test was conducted up to 75% bio components when increasing biodiesel share, deterioration [minor] of fuel performance constraints is noticed. Brake-specific fuel. The results indicated that for the blends B25, B50 and B75, the consumption of fuel increased on average by 3.2%, 8.5%, and 13.8%. The emissions were reduced excluding NOx and HC concentration] and detected the denseness. The brake fuel conversion efficiency reduced to 1.6% for B25, 4.8% for B50 band 7.8% for B75.

Murcak et al [20] have been investigated the effects of performance in a CI engine for altered injection timings using ethanol-diesel blends. The engine power is maximum at 10% ethanol with diesel at advance injection at 45^0 crank angle (CA) and 3000 rpm and torque are maximum at 250 CA and 1400 rpm. The brake specific fuel consumption (BSFC) is minimum at advance injection at 35^0 CA and 1200 rpm for 20% ethanol with diesel.

Venkata Sundar Rao et al [21] have been completed a review for designing and developing the parts of the IC engine suitable for alternate fuels without affecting the performance. From the published literature it is clearly observed that no studies available on the design of IC engine parts such as a piston, piston rings, combustion chamber, liner, suitable for using alternative fuel for better performance and emissions.

From the literature review, it was observed that several studies have been carried out on CI engine to study performance and exhaust emissions with different bio-diesel blends. However, the combustion behavior study of ethanol-diesel blends with additive 1,4 Dioxane is limited compared to studies of performance and emission features. So present study is focused for the improvement of combustion, performance and emission features of DICI engine than other studies with different ratios of diesel-ethanol emulsions at variable load (brake power) conditions and fixed engine speed at 1500 rpm.

II. MATERIALS AND METHODS

The engine tests have been performed on a DICI [single cylinder 4 strokes] water cooled engine as shown in Figure 1. In present study ethanol blends were tested to find out the effects of different biodiesel blends on performance, exhaust gas emissions and combustion behavior using D80 E10 (80% Diesel and 10% Ethanol) D70 E20 (70% Diesel and 20% Ethanol), D60 E30 (60% Diesel, 30%, and Ethanol), and D50 E40 (50% Diesel, and 40% Ethanol) and10% blends added with 1,4 Dioxane additive for better combustion to enhance the performance and reduce the emissions.

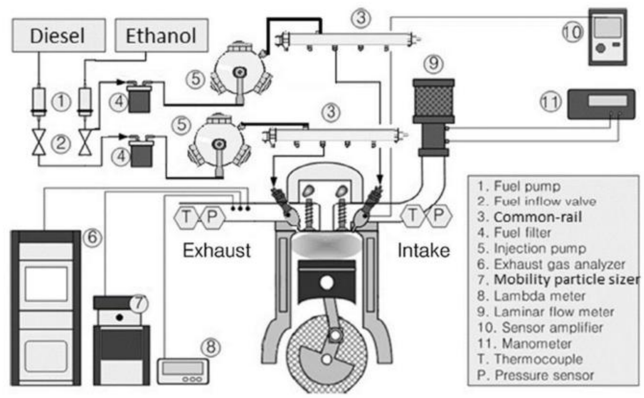


Fig. 1 Compression Ignition Engine Experimental Setup

Tables 1, 2 and 3 shows the engine specifications, properties of fuels and instruments used for the experiment for the measurement of various parameters during the test.

Table 1. Diesel Engine Specifications

Particulars	Specifications
Engine Type	Single cylinder 4 Stroke Diesel engine
Make	Kirloskar TV-1 Engine
Rated brake power	5.2 kW(7HP)
Compression ratio Bore × Stroke	17.5:1 87.5 mm × 110 mm
Speed	1500 rpm
Injection Pressure	220 kgf/cm^2
Ignition timing	23^0 before TDC

Ignition system	Compression Ignition
Loading Device	Eddy current dynamometer
Orifice Diameter	0.02 m
Dynamometer arm length	0.195 m

Table 2 Fuel Properties

Property of fuel	**Diesel**	**Ethanol**	**D50: E40**
Density @ 15 °C in gm/cc	0.8289	0.789	0.8184
Kinematic viscosity @ 40°C	4	1.20	2.84
Specific gravity @ 15°C	0.81	0.796	0.82
Flash point (°C)	74	13	13
Calorific value (kJ/kg)	44600	26600	39132
Cetane number	45-55	5-8	46

Table 3 Instruments and its purpose

Instrument Used	**Purpose**
Eddy current dynamometer	To apply a load to the engine
Tachometer	To measure crankshaft speed RPM
Chromel -Alumel (k-type) thermocouple	To measure exhaust gas temperature
AVL di gas 444 analyzer	To measure HC, NOx, CO, and CO2
Particle size analyser	To measure PM
Smoke meter	To measure smoke density
The water-cooled piezoelectric pressure transducer	To measure combustion chamber pressure

The optimum mixture ratio of D50: E40 was considered, for achieving better combustion features of blends. The pure ethanol was blended with diesel fuel easily at the atmospheric condition and tested in the engine. The engine was tested under various brake power such 1 Nm, 2.1 Nm, 3.1 Nm, 4.1 Nm, and 5.2 Nm without any modification. The engine was run at the low speed of 1500 rpm to avoid instability at maximum load condition. First, the engine was tested with pure diesel fuel for variable loads conditions such as 1 Nm, 2.1 Nm, 3.1 Nm, 4.1 Nm, and 5.2 Nm respectively after warm up for about 30 minutes at 1500 rpm. Test results were monitored at above load conditions to compare with the results of biodiesel blends. The tests were repeated to get steady results and take the average value for calculations. Further, the tests have been conducted with a different ratio of biodiesel blends following the same procedure for pure diesel and recorded the results.

III. RESULTS AND DISCUSSION

An experimental study has been carried out for combustion performance and emission features of the blends on DICI engine and results were analyzed and discussed in following sections.

3.1 Effect of blends on Engine performance parameters

3.1.1 Brake Specific Fuel Consumption (BSFC)

The specific fuel consumptions variation with different brake power for various ratio of blends D80 E10 (80% Diesel and 10% Ethanol) D70 E20 (70% Diesel and 20% Ethanol), D60 E30 (60% Diesel, 30%, and Ethanol), and D50 E40 (50% Diesel, and 40% Ethanol) and10% blends added with 1,4 Dioxane additive and diesel fuel is shown in Figure 2. The results depict that when load and ethanol percentage in diesel fuel increases the SFC decreased. For diesel-ethanol emulsion (D50 E40), the SFC is lower compared to other emulsified fuels. The SFC obtained at maximum brake power was 0.261, 0.269, 0.278, 0.287 and 0.262 kg/kwhr respectively.

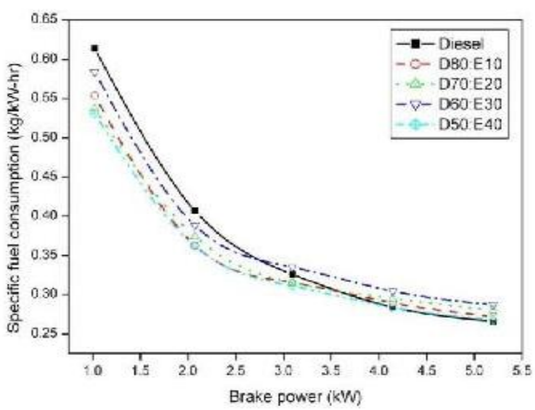


Figure 2 Variation of Specific fuel consumption at various loads for diesel and different blends

3.1.2 Brake thermal efficiency (BTE)

The brake thermal efficiency variation with different loads on the engine is illustrated in Figure 3. It illustrates that the diesel fuel has lower brake thermal efficiency than all blended fuels. The brake thermal efficiency has been improved such as 30%, 31.1%, 32.8%, 34.1%, and 35.7%, for diesel fuel, D60E30, D70E20, D80E10 and D50E40 respectively at maximum brake power. It reveals that efficiency increases with the addition of ethanol in diesel, however, it is high for D50E40 and low for D60E30 due to emulsification of diesel with ethanol and additives chemical composition. The fluctuation of efficiency sometimes due to mixing, ignition delay, and combustion processes.

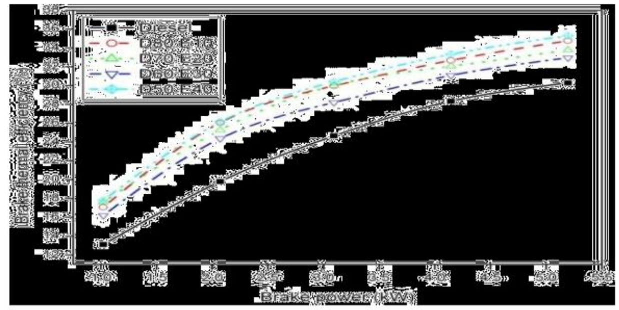


Figure 3 Variation of Brake thermal efficiency at various loads for diesel and different blends

3.1.3 Exhaust Gas Temperature (EGT)

The exhaust gas temperature variation for different diesel blends at various engine loads are illustrated in Figure 4. When HRR is increased, exhaust gas temperature also increases with a variation of the loads for clean diesel fuel and all diesel blends. It is observed that at no load conditions, the exhaust gas temperatures (^{0}C) of 131, 125, 121, 116 and 112 whereas at full load condition 571, 565, 558, 553, and 548 respectively for different blends. When the ethanol content increases to blend the exhaust gas temperature decreased at low and medium loads, because of the higher latent heat of vaporization of ethanol. Similarly, the exhaust gas temperature increases while ethanol content increases at higher loads due to an increase of HRR during combustion.

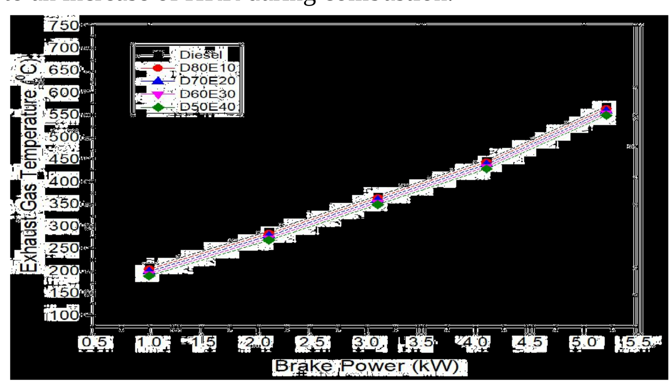


Fig. 4 Variation of exhaust gas temperature at various loads for diesel and different blends

3.2 Effect of blends on engine-emissions

3.2.1 Nitrogen Oxide (NOX)

Nitrogen oxide NOx is a mixture of nitric oxide (NO) and nitrogen dioxide (NO2). The NOx variation at different loads for pure diesel and different blends are illustrated in Figure 5. From the results it is obvious that the emission of NOx all fuel blends and for diesel found minimum at lower load but when ethanol contents in the blend increases, NOx emission also increased.

The NOx emission obtained was high (612 ppm) at full load condition for D50E40 blend and that for diesel is low (500 ppm because NOx formation mostly depends on oxygen concentration. cylinder temperature and fuel-air present time. The NOx emission reduction of 20%, 12%, and 9% were obtained at different loads conditions**.** The combustion temperature reduces because ethanol has the higher latent heat of evaporation which leads to decrease NOx formation at very lean fuel mixture conditions.

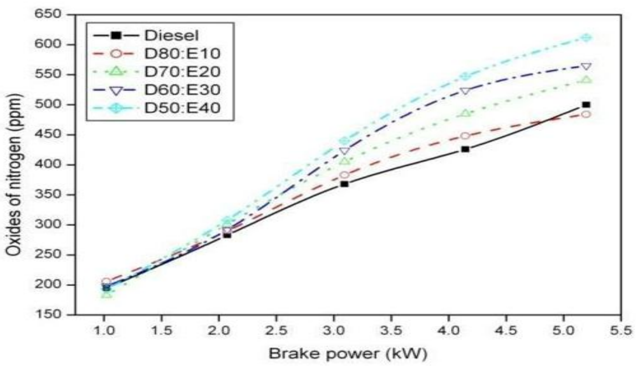


Figure 5 Variation of NOx at various loads for diesel and different blends

3.2.2 Hydrocarbon (HC)

The hydrocarbon variation at different loads for diesel and various compositions of ethanol in diesel is illustrated in Figure 6. The result reveals that HC concentration varying as 63 ppm, 33 ppm and 19 ppm at various load conditions for a percentage of ethanol contents compared to clear diesel. The vaporization of ethanol reduces as latent heat of vaporization is high for ethanol as well as weakened combustion leads to lower the combustion temperature. The formation of HC has been enhanced due to poor combustion. Also, it is observed that HC emission (ppm) is less at low load and increases at high brake power for all fuel blends. Further, HC emission is higher (63 ppm) for D50E40 blend than pure diesel 38 ppm at full load condition. However, HC emissions decreased due to the enhanced mixing of air and fuel so when load increases combustion improved.

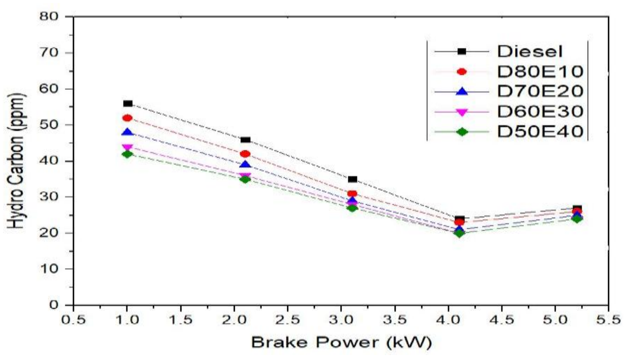


Figure 6 Variation of HC at different load for diesel and different blends

3.2.3 Carbon monoxide (CO)

The CO has been produced from the engine during combustion process either due to lower in-cylinder temperature or the deficiency of oxygen which is inadequate to support the combustion. The CO is toxic to human so it is essential to reduce CO emission. The carbon monoxide (CO) emissions variation with various engine load for diesel and different blends are illustrated in Figure 7. The result shows that the CO decreased initially with load and latter increased abruptly up to full load due to poor mixing of air and fuel in the rich mixture for all the fuel blends. However, the CO emissions are low for blends than diesel due to their further complete oxidation.

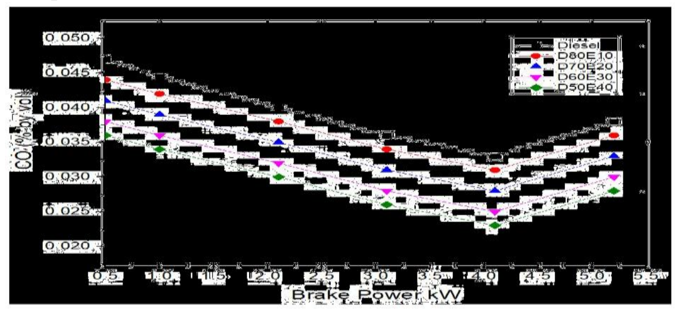


Fig. 7 Variation of CO with a load for diesel and different blends

3.2.4 Carbon dioxide (CO2)

The higher concentrations of CO2 play a vital role in global warming in the atmospheric air. Figure 8 shows the carbon dioxide emission variation with different loads for pure diesel and various diesel blends. The results show that the concentration of CO2 increases with a load of pure diesel and different blends due to higher in-cylinder temperature, extra oxygen availability which improved combustion. At low engine load, the CO2 emissions are low because the combustion rate is poor due to the cooling effect and leaner mixture. At high engine load, CO2 decreases due to poor mixing and reduced air/fuel ratio. However, it is seen that higher amount of CO2 is emitted by D50E40 emulsion than pure diesel. The maximum carbon dioxide emission of 0.095% was obtained at full load condition. It is due to the high amount of oxygen present in the blend during combustion.

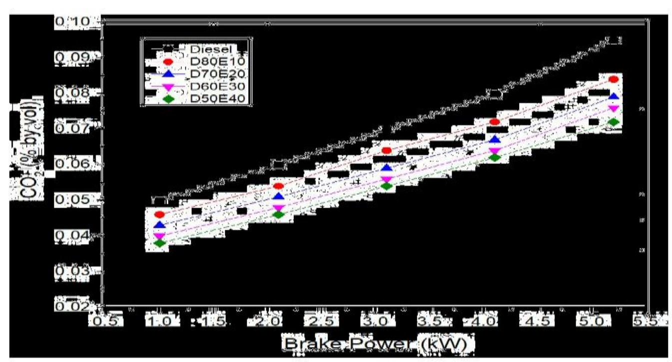


Figure 8 Variation of carbon dioxide with a load of diesel and different blends

3.2.4 Smoke Density

Figure 9 illustrates the smoke density variation with different loads for diesel and different blends. The result reveals that smoke density increases with increase in ethanol composition, with an increase of load for clear diesel and various blends because ethanol has less number of carbon atoms than diesel and decreases ignition delay with increasing brake power. The air temperature at fuel injection increases when brake power increased, which reduce the ignition delay. The smoke density has been found increase at low load condition, then little decrease at medium load and then increases for the entire load range due to rich mixing. However, it is clear that the smoke density is decreased at high brake power. The smoke density at higher loads for the D50E40 blend was lower than pure diesel. The mass of diesel fuel burned increases due to ignition delay increases which helps to reduce the particulate matter and smoke density.

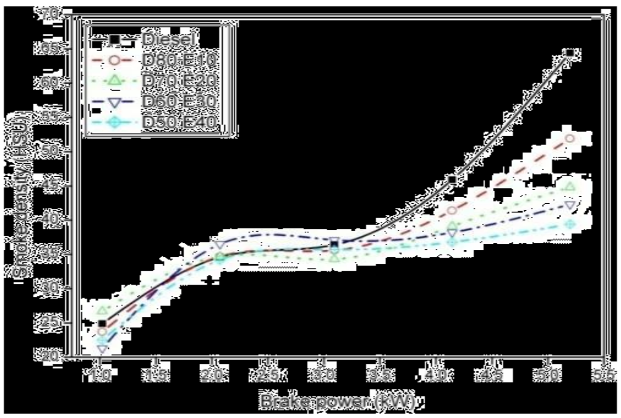
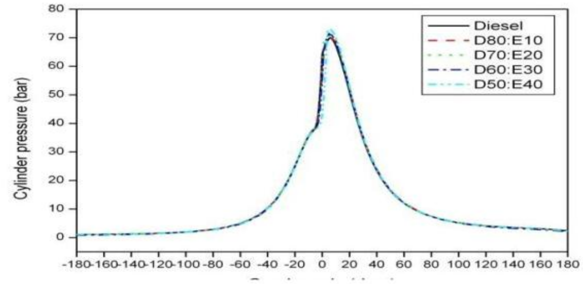


Figure 9 Variation of smoke density with a load of diesel and different blends

3.3 Effect of blends on combustion parameters

3.3.1 In-cylinder pressure and rate of pressure rise (MEP)

The cylinder pressure variation with a crank angle for pure diesel and various concentrations of blends are shown in Figure 10. The result reveals that the cylinder pressure increases first, then reach peak pressure, and when crank travel, the pressure decreases during a particular period. It is observed that the peak pressure happens near to top dead center (TDC) at improved brake power. The maximum cylinder pressure is achieved for ethanol at a higher percentage in blends than diesel. The cylinder pressure variation with crank angle at full load is very close to each other for pure Diesel and blends. However, the higher cylinder pressure of 74.9 bar was obtained for D50E40 blend at full load condition and 68.8 bar for pure diesel. The peak pressure has been obtained as 73.2, 74, 72.9, 73.5 and 74.9 bar at maximum load condition. The pure diesel consists of air and residual gases during operation and biodiesel blends consist of air, residual gases, and ethanol during operation as the working substance inside the engine cylinder.



Crank Angle (Deg)
Figure 10 Variation in-cylinder pressure with crank angle at full load

3.3.2 Heat release rate (HRR)

The variation of heat release rate with a crank angle for different blends and pure diesel at maximum load is shown in Figure 11. The combustion process is characterized by HRR in CI engines. HRR accelerate the combustion process and convert the chemical energy of fuel into thermal energy rapidly during the combustion process. The rate of pressure rise and the cylinder pressure are important parameters for HRR calculation. After the start of fuel injection, the heat release is zero for short period due to the lagging of combustion. Also, after the end of fuel injection, till the remaining fuel is consumed, the heat release rate decreases. HRR rises rapidly when autoignition occurs because premixed fuel burns during combustion which characterize the heat release rate. The combustion rate decreases after premixed fuel were consumed due to a slower rate of mixing controlled combustion.

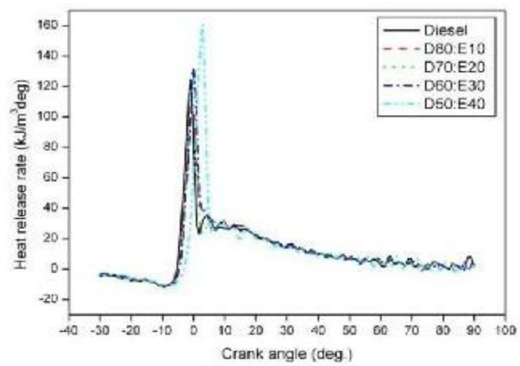


Figure 11 Variation in heat release rate with crank angle at full load

The result shows that the maximum HRR was obtained for D50E40 blend comparing to other blends and pure diesel. The HRR obtained for D50 E40 blend was162.1 KJ/m^3K and 121.2 KJ/m^3K for Diesel at full load condition.

It is observed from the figures 10 and 11 that the cylinder pressure and heat release rate increases with crank angle at full load condition and both values are maximum when the crank angle is zero that is the piston is at top dead center.

IV. CONCLUSIONS

A detailed experimental study of DICI engine has been carried out to investigate performance, emissions and combustion features for biodiesel composed of diesel, ethanol and1,4 dioxane additive for different loads. At a certain high engine load, the brake thermal efficiency increased to 14.7% and brake specific fuel consumption decreased to 8.7% for D50 E40 blend. The exhaust gas temperature starts from 131 ^{0}C to 112 ^{0}C for pure diesel at zero brake power and the exhaust gas temperature starts from 548 ^{0}C and reaches to 571^{0}C at maximum load. The HRR increases due to faster burning of the premixed ethanol–air–diesel mixture and thus performance was improved. At full load condition, the best emissions have been obtained as per the results. The result shows that for D50E40 blend Hydrocarbon (HC) emission was higher than diesel. The NOx emission variation found from 63 ppm to 37 ppm, nitrogen (NO_X) emission found as 612 ppm for blends whereas it is 500 ppm for pure diesel. The CO emission 0.036% is lower for D50E40 blend than pure diesel but CO_2 0.05% is higher for blend than Diesel. The smoke density for the D50E40 blend was lower 36 [HSU-Hartridge smoke units] than pure diesel. The pressure in the engine cylinder is peak as 74.9 bar for blends and that of diesel is 68.8 bar. The heat release rate of D50 E40 blend is 162.1 KJ/m^{3}K and that for clean diesel is 121.2 KJ/m^{3}K at maximum load. The DICI Engine operated with biodiesel blends is better for improvement of performance, emission and combustion features. Thus, it is finally concluded that the study of various fuel blends in this paper helps for improving efficiency, decreasing emissions and better combustion for the suitability of future automotive fuels.

REFERENCES

1. Arkadiusz Jamrozik, The effect of the alcohol content in the fuel mixture on the performance and emissions of a direct injection diesel engine fueled with diesel methanol and diesel-ethanol blends, Energy Conversion and Management 148 (2017) 461–476.
2. R. Sathiyamoorthi and G. Sankaranarayanan, The effects of using ethanol as an additive on the combustion and emissions of a direct injection diesel engine fuelled with neat lemongrass oil-diesel fuel blend, Renewable Energy 101 (2017) 747e756.
3. Mithun Das, Muktuk Sarkar, Amitava Datta, Apurba Kumar Santra, An experimental study on the combustion, performance and emission characteristics of a diesel engine fuelled with diesel-castor oil biodiesel blends, Renewable Energy 119 (2018) 174-184.
4. Peng Fu, Xueyuan Bai, Weiming Yi, Zhihe Li, Yongjun Li, Lihong Wang, Assessment on performance, combustion and emission characteristics of a diesel engine fuelled with corn stalk pyrolysis bio-oil/diesel emulsions with Ce0.7Zr0.3O2 Nano additive, Fuel Processing Technology 167 (2017) 474–483.
5. A. Osman Emiroğlu and Mehmet Şen, Combustion, performance and emission characteristics of various alcohol blends in a single cylinder diesel engine, Fuel 212 (2018) 34–40.
6. M. Nadeem, C. Rangkuti, K. Anuar, M.R.U. Haq, I.B. Tan and S.S. Shah, Diesel engine performance and emission evaluation using emulsified fuels stabilized by conventional and Gemini surfactants, Fuel 85 (2006) 2111–2119.
7. T. Prakash, V. Edwin Geo, Leenus Jesu Martin and B. Nagalingam, Effect of ternary blends of bio-ethanol, diesel and castor oil on performance, emission and combustion in a CI engine, Renewable Energy 122 (2018) 301-309.
8. Wan Nor Maawa Wan Ghazali, Rizalman Mamat, H. H. Masjuki and Gholamhassan Najafi, Effects of biodiesel from different feedstocks on engine performance and emissions: A Review, Renewable and Sustainable Energy Reviews, 51 (2015), 585–602.
9. B. Prabakaran and Anurag Udhoji, an Experimental investigation into effects of addition of zinc oxide on performance, combustion and emission characteristics of diesel-biodiesel-ethanol blends in CI engine, Alexandria Engineering Journal (2016) 55, 3355–3362.
10. D.K. Jamuwa, D. Sharma and S.L. Soni, Experimental investigation of performance, exhaust emission and combustion parameters of stationary compression ignition engine using ethanol fumigation in dual fuel mode, Energy Conversion and Management 115 (2016) 221–231.
11. Jeongwoo Lee, Sunyoup Lee and Seokhwan Lee, Experimental investigation on the performance and emissions characteristics of ethanol/diesel dual-fuel combustion, Fuel 220 (2018) 72–79.
12. M. Srinivasa Rao and R.B. Anand, Performance and emission characteristics improvement studies on a biodiesel fuelled DICI engine using water and AlO(OH) nanoparticles, Applied Thermal Engineering 98 (2016) 636–645.
13. Sharanappa, Ch. Suryanarayana Murthy and Rana Prathap Reddy, Performance and emission characteristics of a Kirloskar HA394 diesel engine operated on fish oil methyl esters, Renewable Energy 35 (2010) 355–359.
14. S.M. Palash, H.H. Masjuki, M.A. Kalam, B.M. Masum, A. Sanjid and M.J. Abedin, State of the art of NOx mitigation technologies and their effect on the performance and emission characteristics of biodiesel-fueled Compression Ignition engines, Energy Conversion and Management 76 (2013) 400–420.
15. C. Swaminathan and J. Sarangan, Performance and exhaust emission characteristics of a CI engine fueled with biodiesel (fish oil) with DEE as an additive, biomass, and Bioenergy 39 (2012), 168 -174.
16. S.A.Shahir, H.H.Masjuki, M.A.Kalam, A.Imran and A.M.Ashraful, Performance and emission assessment of diesel–biodiesel–ethanol/bioethanol blend as a fuel in diesel engines: A Review, Renewable and Sustainable Energy Reviews, 48 (2015), 62–78.
17. M.A. Asokan, S. Senthur prabu, Shikhar Kamesh and Wasiuddin Khan, Performance, combustion and emission characteristics of a diesel engine fuelled with papaya and watermelon seed oil bio-diesel/diesel blends, Energy 145 (2018) 238-245.
18. Jamil Ghojel, Damon Honnery, and Khaled Al-Khaleesi, Performance, emissions and heat release characteristics of direct injection diesel engine operating on diesel oil emulsion, Applied Thermal Engineering 26 (2006) 2132–2141.
19. Maciej Mikulski, Kamil Duda and Sławomir Wierzbicki, Performance and emissions of a CRDI diesel engine fuelled with swine lard methyl esters–diesel mixture, Fuel 164 (2016) 206– 219.
20. Ahmet Murcak, Can Hasimoglu, _Ismet Çevik, Murat Karabektas, and Gökhan Ergen, Effects of ethanol [content of 5%, 10% and 20% by volume]–diesel blends to the performance of a DI diesel engine for different injection timings, Fuel 109 (2013) 582–587.
21. Mr. Venkata Sundar Rao. Ka, Dr. S.N. Kurbetb and Dr. Vinay V. Kuppast, A Review on Performance of the IC Engine Using Alternative Fuels, Materials Today: Proceedings 5 (2018) 1989–1996.

AUTHOR PROFILE

Prof. Dr. S. SUYAMBAZHAHAN had completed Doctoral Degree (Ph.D.) from India's premier institution, Indian Institute of Technology Madras (IITM). His area of Specialization is Computational Fluid Dynamics (CFD) and Heat Transfer [Thermo-Fluids] in the field of Mechanical Engineering. He has 30+ years of experience in Administration, Academic and Research in NBA, NAAC and ABET Accredited Colleges and University. He is continuously working as Professor and Principal (Head of the Institution) in reputed Engineering Colleges since 2nd June 2003. He is the Recognized Research Supervisor for 5 Universities, Reviewer for 5 international Journals & member of 18 Professional Bodies.