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Performance and Emission Improvement of Biodiesel Fueled Diesel Engine with Exhaust Gas Recirculation and Ethyl Hexyl Nitrate Additive

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Abstract

Performance, combustion and emission results of the diesel engine fueled with biodiesel blends with cetane improver as additive are presented in this paper. Cetane improver Ethyl Hexyl Nitrate (EHN) as 0.5% and 1% by volume is added as an additive to diesel-biodiesel blends. Experiments were conducted on a single cylinder, four stroke, and naturally aspirated, direct injection diesel engine with the said fuels using Exhaust Gas Recirculation (EGR) to analyze the performance, combustion and emissions. Experimental results reveal that both cylinder pressure and Heat Release Rate (HRR) decreased with increase in blend percentage and EGR as well. With increase in EHN percentage, CO and HC emissions decreased considerably while NO_x *decreased marginally. Smoke increases with increase in both EHN and EGR, however, at a particular EGR, blends with cetane improver present the better performance with improved emissions.*

Keywords: *Biodiesel, Combustion characteristics, Cetane improver, cylinder pressure, EGR, Emissions.*

1. Introduction

Biodiesel proves to be a viable alternative for petro-diesel as the properties of the biodiesel are almost similar to diesel. One advantage of biodiesel is its oxygen content, which is directly responsible for the reduction of the emissions like Carbon Monoxide (CO), Hydro Carbon (HC) and Particulates [1]. However, this decrease is accompanied by an increase in the Nitrogen Oxides (NO_x) emissions as reported by so many researchers [2-6]. Furthermore, viscosity of biodiesel is higher than that of diesel, which affects some processes like atomization and fuel-air mixing. This problem can be overcome by the addition of certain additives to biodiesel [7]. There are several additives such as oxygenates, bio-additives and cetane improvers. Cetane number is actually a measure of fuel's ignition delay. Higher cetane fuels will have shorter ignition delay periods than lower cetane fuels in a particular diesel engine [8]. Higher cetane numbers reduced the regulated and unregulated emissions including NO_x in addition to the improvement in the engine performance [9-11]. Several authors [12-14] reported that cetane improver in combination with oxygenates improved engine performance in addition to the reduction in emissions. However, these additives are not as effective as EGR for the reduction of NO_x emissions. Exhaust gas recirculation is recirculation of a part of the exhaust gases into the intake, which helps in reducing the NO_x[15]. Significant reductions in NO_x emission were

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observed with the increased EGR rates [16]. However, this reduction is accompanied by an increase in other emissions like smoke and particulates [17,18]. In addition to that, higher EGR levels result in the development of gaseous emissions like hydrocarbons and increased particle density and size in the exhaust [19–23].To offset the adverse effects of EGR on engine performance and other emissions, EGR in combination with either additives or modification in other operating parameters likes injection timing and injection pressure can be an effective solution [24]. EGR, when combined with proper injection timing and injection pressure can reduce the NO_x emissions with a trade-off on smoke and efficiency [25].

In the present work, the combined effect of EGR and cetane improver EHN is considered for reducing the NO_x emissions and improving the combustion and emissions when diesel-biodiesel blends are used.

2. Test Fuels

Usually, biodiesel is produced from vegetable based oils, animal fats, or waste cooking oils by chemically reacting them with an alcohol (usually methanol) and a catalyst either sodium or potassium hydroxide (KOH). In the present experimental investigations, biodiesel derived from fish oil by transesterification is used for blending it with diesel in varying proportions.

Biodiesel yield percentage: The percentage yield of biodiesel at different molar ratios (i.e methanol to oil ratio) namely 1:4, 1:6 and 1:8 and different concentrations of KOH such as 0.25, 0.5, 0.75 and 1 by weight percentage (wt.%) is presented in Figure.1. Figure shows that, highest biodiesel yield is obtained with 0.5 wt.% KOH and 1:6 molar ratio keeping other parameters like reaction time (one hour) and temperature (60^0C) constant. The percent yield of biodiesel is calculated on weight basis with respect to the oil used in transesterification [26].

$$\text{Yield \%} = \frac{\text{Weight of the methyl esters}}{\text{Weight of oil used}} \text{x } 100$$

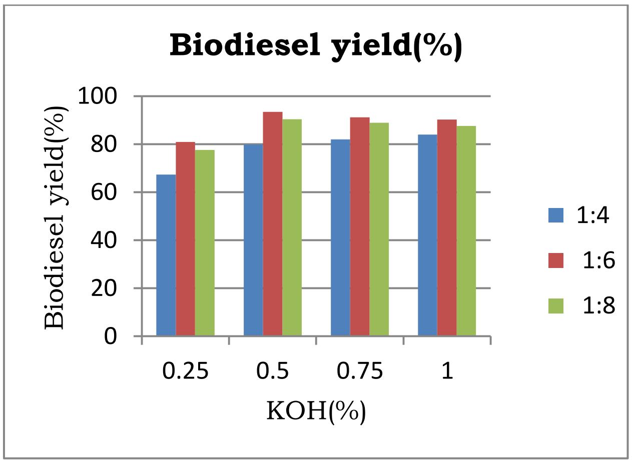


Figure 1. Biodiesel Yield (%) for Different Molar Ratios and KOH Percentages

The properties of the fuels (diesel and biodiesel) such as viscosity, flash & fire points and dissolved oxygen etc. are presented in Table.1; while the properties of the EHN are presented in Table.2. Biodiesel is blended with diesel in different proportions like 20, 30 and 40 percentages. Additive 2-Ethyl Hexyl Nitrate (EHN) is added as 0.5% and 1% by volume to the said diesel-biodiesel blends. Diesel- biodiesel blends with cetane improver EHN are designated as B20E0.5, B30E0.5, B40E0.5, B20E1, B30E1, and B40E1(i.e B20E0.5 implies biodiesel 20% with cetane improver EHN 0.5% and remaining diesel by volume).

Table 1. Properties of the Diesel and Biodiesel (B100)

Name of the fuel sample→ ↓ Characteristics	diesel	biodiesel(B100)
Flash point(°C)	56	161
Fire point(°C)	60	172
Kinematic viscosity(Centi stokes)	3.15	10.15
Density(gm/cm^3)	0.83	0.896
Lower calorific value(KJ/kg)	42500	37250
Dissolved oxygen (ppm)	0	8.2

Table 2. Properties of EHN

Property	Value
Chemical formula	$C_8H_{17}NO_3$
Flash point, °C	81
Viscosity at 20°C	1.8
Density(gm/cm^3)	0.8
Heting value, KJ/kg	29855
Melting point, °C	< -50
Flammability	Non-Flammable
Vapor pressure, at 20°C	27 mmHg

3. Experimental Set-up and Methodology

The engine used for the experimentation to investigate the combined effect of the EHN and EGR on diesel-biodiesel blends is shown schematically in Figure.2, which is a computerized single cylinder four stroke naturally aspirated direct injection air cooled diesel engine. Specifications of the test engine are presented in Table.3. An eddy current dynamometer 080CN is used for loading the engine. The engine is directly coupled to the eddy current dynamometer; the engine and dynamometer are interfaced to a control panel which is connected to a computer. For measuring the pressure variation with the crank angle in the cylinder, the engine is equipped with an AVL GH12D miniature pressure transducer and AVL 617 Indi meter software with a data acquisition system consisting of sensors, analog to digital card and software package for acquisition of the data of the engine parameters and processing. An AVL five gas analyzer FGA512 is used for measuring the CO, HC, and NO_x, and AVL smoke meter OMS103 is used for measuring the smoke opacity. For circulation of exhaust gases into the intake manifold, an EGR set up is provided which consists of an exhaust drum for storing the exhaust gases, a control valve to vary the EGR rate and a manometer for measuring the flow rate of EGR. The rate of EGR is varied manually with the help of a control valve.

Table 3. Specifications of the Test Engine

Property	Value
Rated power	4.4 kW
Bore	87.5mm
Stroke length	110 mm
Swept volume	0.661 L
Compression ratio	17.5:1
Rated speed	1500 rpm
Injector operating pressure	210 bar
Start of injection	24.9 ^{0} bTDC

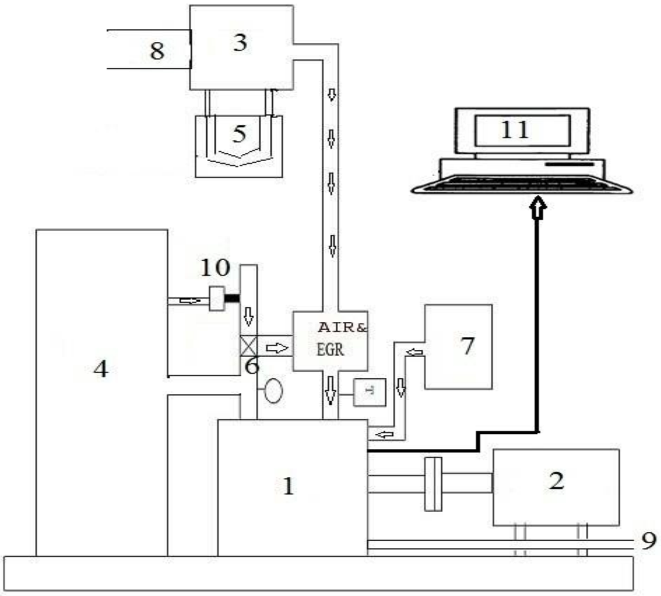


Figure 2. Schematic Diagram of the Experimental Set-up

(1) Test Engine; (2) Dynamometer; (3) Air Tank; (4) Exhaust Gas Drum; (5) U-Tube

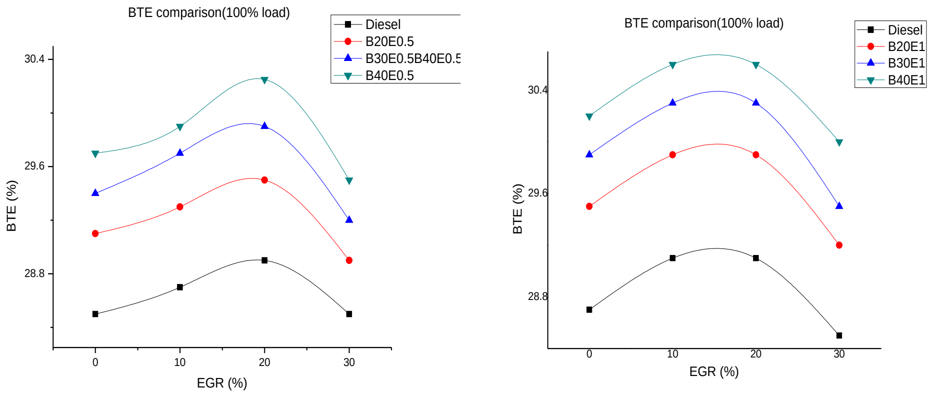
Manometer: (6) EGR Valve; (7) Fuel Tank; (8) Orifice; (9) Exhaust Gas Analyzer; (10) Exhaust Probe; (11) Computer.

4. Results and Discussion

In this study, diesel is used as a baseline fuel to study the effect of fuel blends with EHN under EGR to evaluate engine performance, combustion and emissions. The results of blends with additive are compared with baseline fuel to find out the optimum blend and EGR rate which could improve the engine performance and emissions.

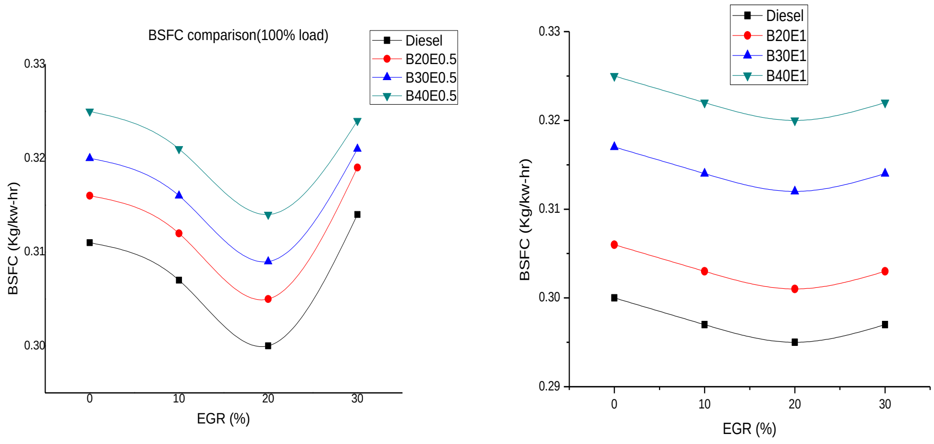
4.1 Performance Analysis

Figure 3 (a) and (b) illustrates the variation of BTE with EGR mass fraction for pure diesel, diesel-biodiesel blends with 0.5% and 1% EHN respectively at 100% load. BTE of all the fuels increases up to 20% EGR and thereafter it decreases. The improvement in BTE with the combined effect of both EGR and EHN is about 5-6%. This is due to the improvement in combustion resulting from the addition of the cetane improver to the blends and increased combustion velocity, as EGR increases intake charge temperature. However, at higher EGR rates, the charge dilution effect with the recirculation of exhaust gas results in lower flame velocity and hence deterioration of the combustion, results in lower BTE. Figure 4 (a) and (b) illustrates the variation of BSFC with EGR mass fraction for diesel, diesel-biodiesel blends with 0.5% and 1% EHN respectively at 100% load. BSFC increases with the increase in blend percentage while it decreases up to 20% EGR and thereafter it increases. The energy content of pure biodiesel is around 12% less than that of diesel, which causes fuel consumption to increase. BSFC decrease of 3% is observed with 20% EGR. This result can be understandable from the increased mass flow rate with the EGR which can compensate for the lower heating value of biodiesel.



a) b)

Figure 3. Effect of Exhaust Gas Recirculation on Brake Thermal Efficiency at 100% Load a) 0.5% EHN b) 1% EHN

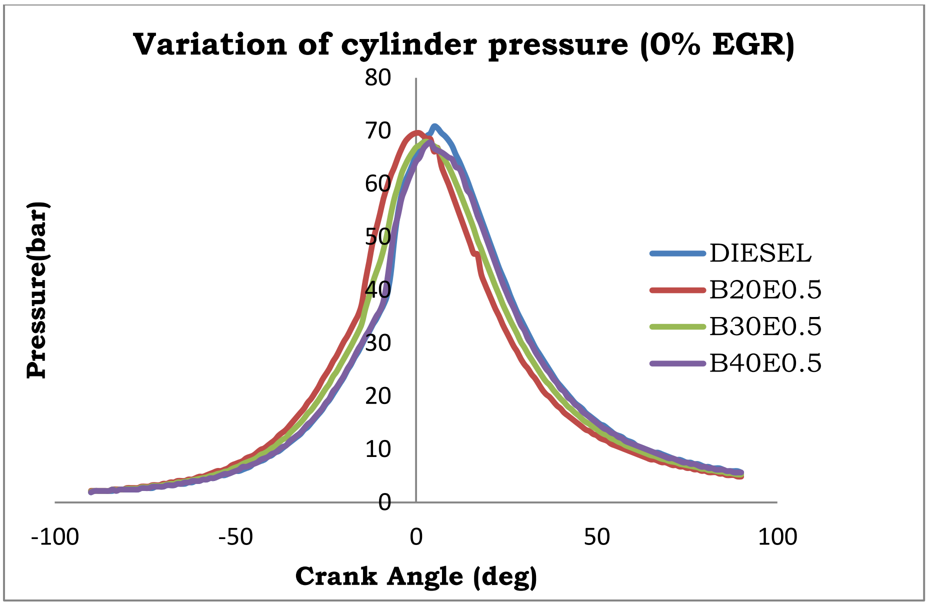


a) b)

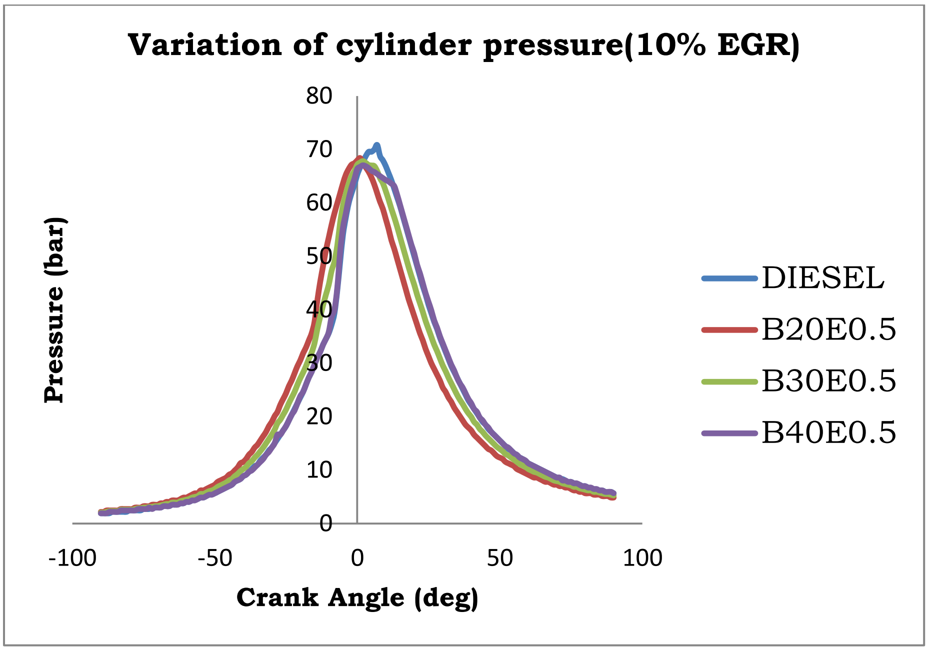
Figure 4. Effect of Exhaust Gas Recirculation on Brake Specific Fuel Consumption at 100% Load a) 0.5% EHN b) 1% EHN

4.2 Combustion Analysis

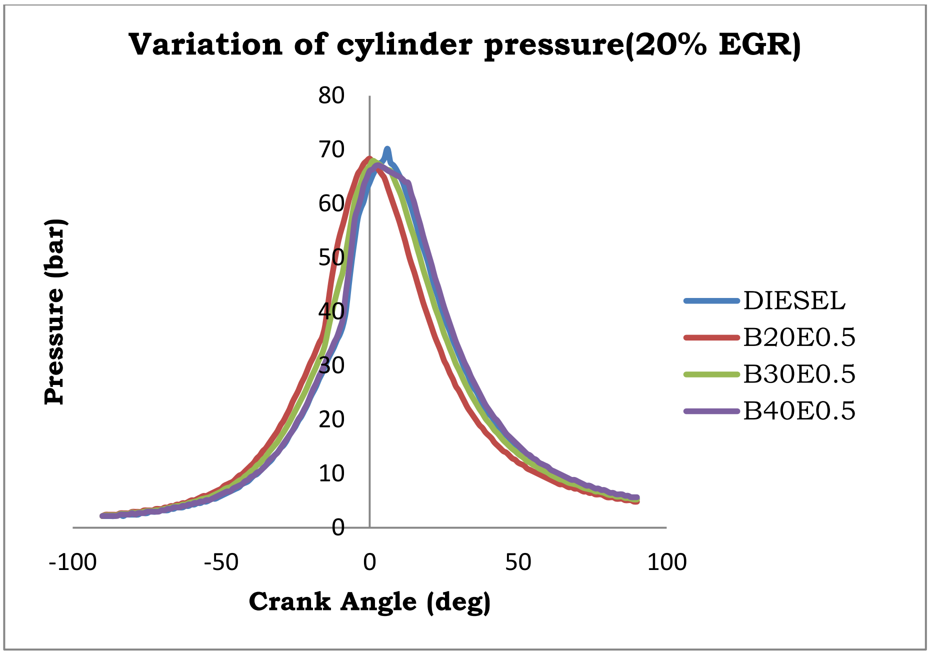
Combustion characteristics results such as cylinder pressure and Heat Release Rate (HRR) versus crank angle at different EGR rates are presented in Figures 5 to 7. Figure 5(a), (b), (c) and (d) show the variation of cylinder pressure with crank angle for diesel, diesel-biodiesel blends with 0.5% EHN at 0%, 10%, 20% and 30% EGR rates respectively while Figure 6(a), (b), (c) and (d) show that of diesel, diesel-biodiesel blends with 1% EHN. It can be observed from these figures that the biodiesel blends and diesel show the similar trends for cylinder pressure. Reduced ignition delay of the blends is evidenced by preponed peak pressures when compared with that of baseline fuel. Blends demonstrate a marginal decrease in peak pressures when compared with that of diesel. Peak cylinder pressure also decreases slightly with increase in EHN percentage in the blends. For example, at a particular EGR, maximum cylinder pressure (P_{max}) of 72.387 bar at 6^0 aTDC has been recorded for diesel while P_{max} of 68.8745, 68.008, and 67.932 bars for B20E0.5, B30E0.5 and B40E0.5; 68.045, 67.82, and 66.60 bar is recorded for B20E1, B30E1 and B40E1 at 4^0 aTDC respectively**.** Cylinder pressure also decreases marginally with increase in EGR rate. Higher cetane number of biodiesel with the addition of cetane improver and fatty acid composition of biodiesel are the main reasons for early start of combustion and shorter ignition delay. Figure 7 (a), (b), (c) and (d) show the variation of heat release rate with crank angle for diesel, diesel-biodiesel blends with 0.5% EHN at 0%, 10%,20% and 30% EGR rates respectively while Figure 8 (a), (b), (c) and (d) show that of diesel, diesel-biodiesel blends with 1% EHN. From these, it can be seen that the first peak of heat release rate of the blends is slightly less than that of diesel which is evidenced by the reduction in combustion temperatures of the blends when compared to that of diesel. Peak HRR of biodiesel blends is preponed by about 3^0 CA when compared with that of diesel. Peak HRR of 73.632 kJ/m^3-deg at 11^0 bTDC is recorded for diesel while 71.942, 69.531 and 68.307 kJ/m^3-deg at 8^0 bTDC are recorded for B20E0.5, B30E0.5 and B40E0.5 respectively. Peak HRR of 76.104, 74.48 and 70.89 kJ/m^3-deg at same CA are recorded for B20E1, B30E1 and B40E1 respectively. The reason for lower HRR of the biodiesel blends with cetane improver when compared to that of diesel is due to their lower heating value, shorter ignition delay and higher viscosity. Further, with increase in EHN percentage also ignition delay is reduced, this can be understandable that the EHN decreases the accumulation of unburned fuel in the premixed phase of combustion.



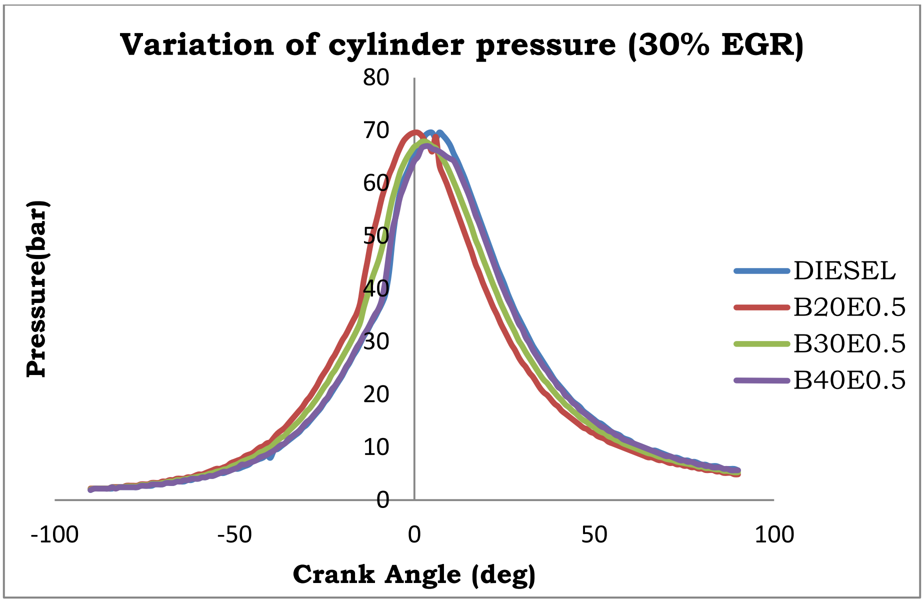
a)0% EGR



b)10% EGR



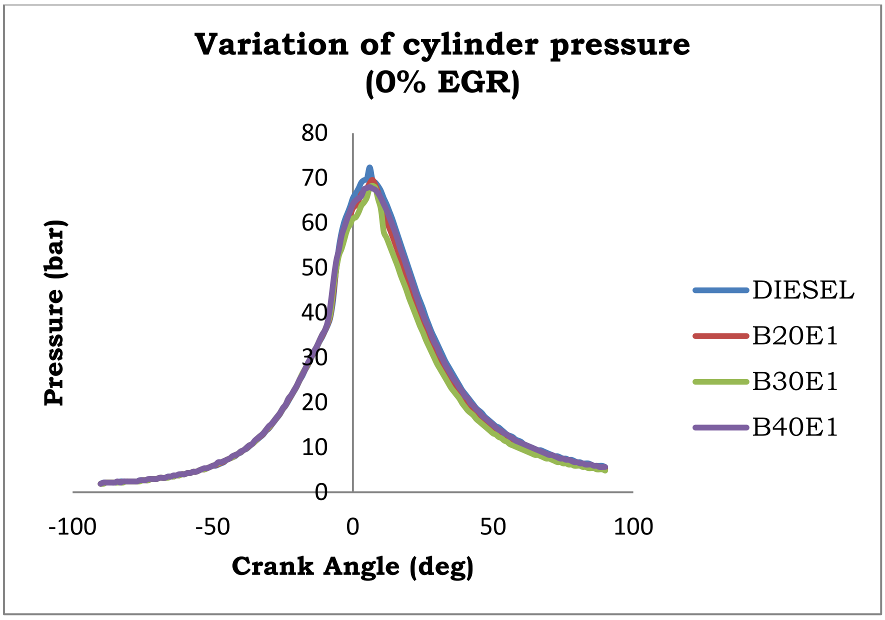
c)20%EGR



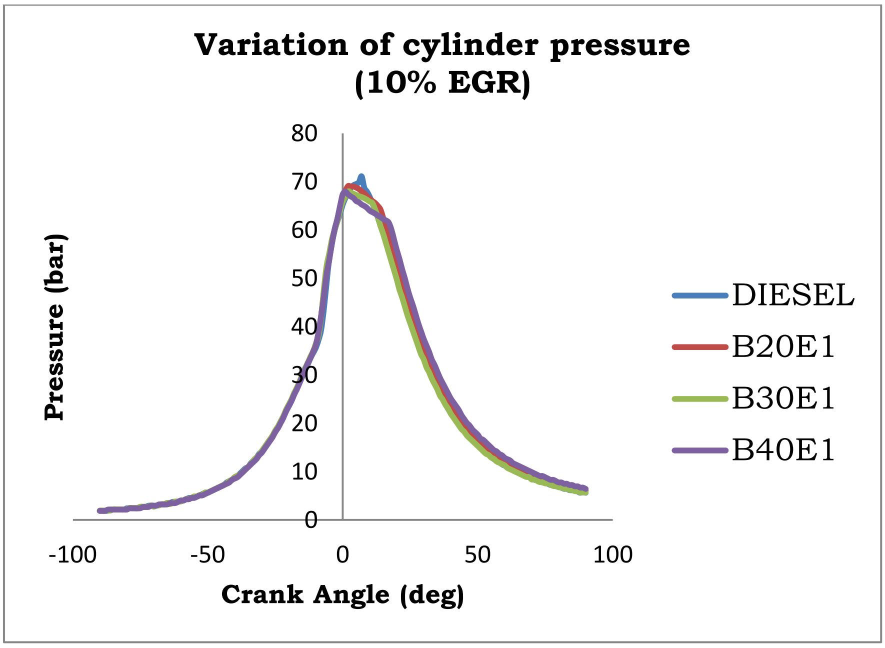
d)30%

EGR

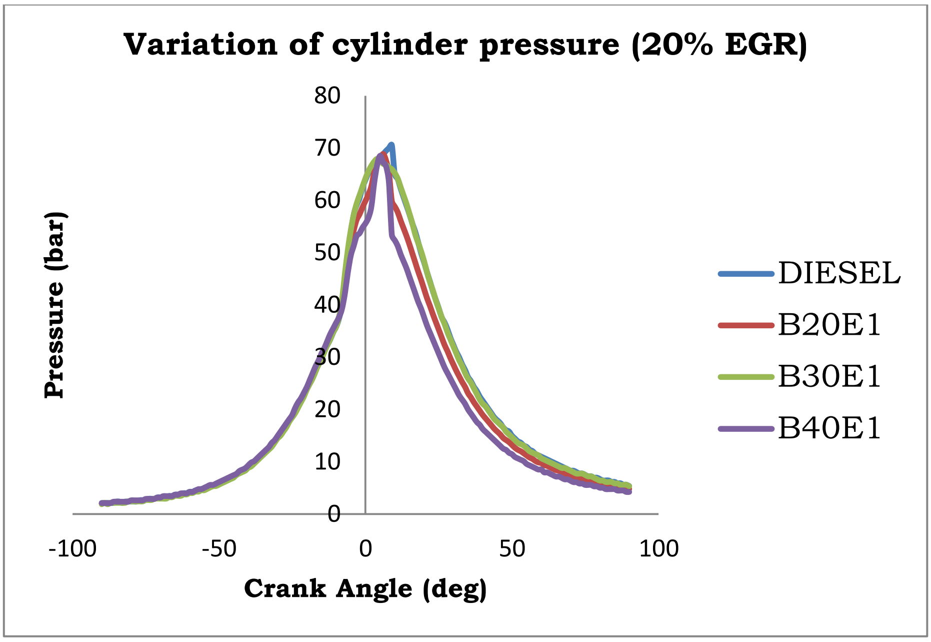
Figure 5. Variation of Cylinder Pressure with Crank Angle at Different EGR Rates (0.5% EHN) a) 0% EGR b) 10% EGR c)20% EGR d)30% EGR



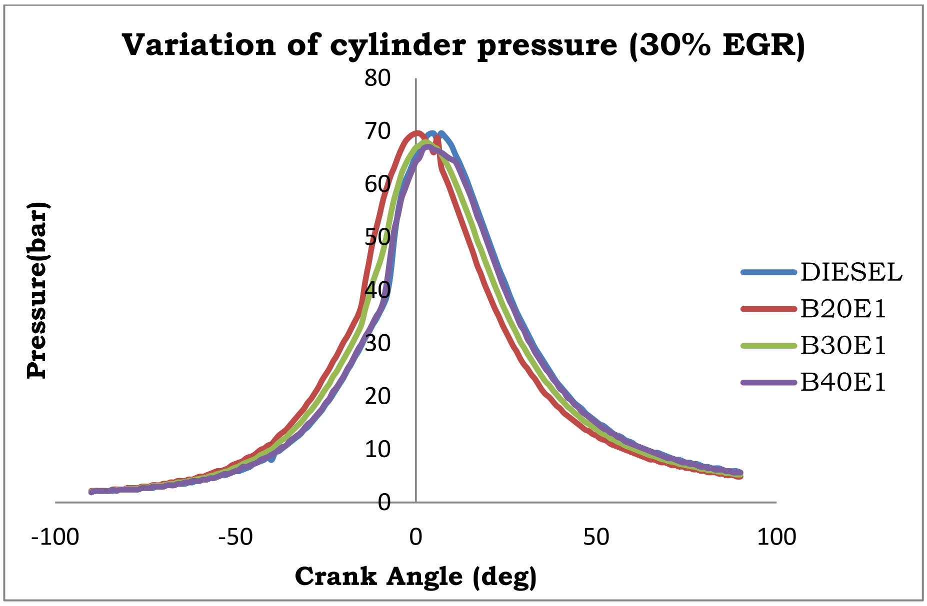
a) 0% EGR



b) 10% EGR

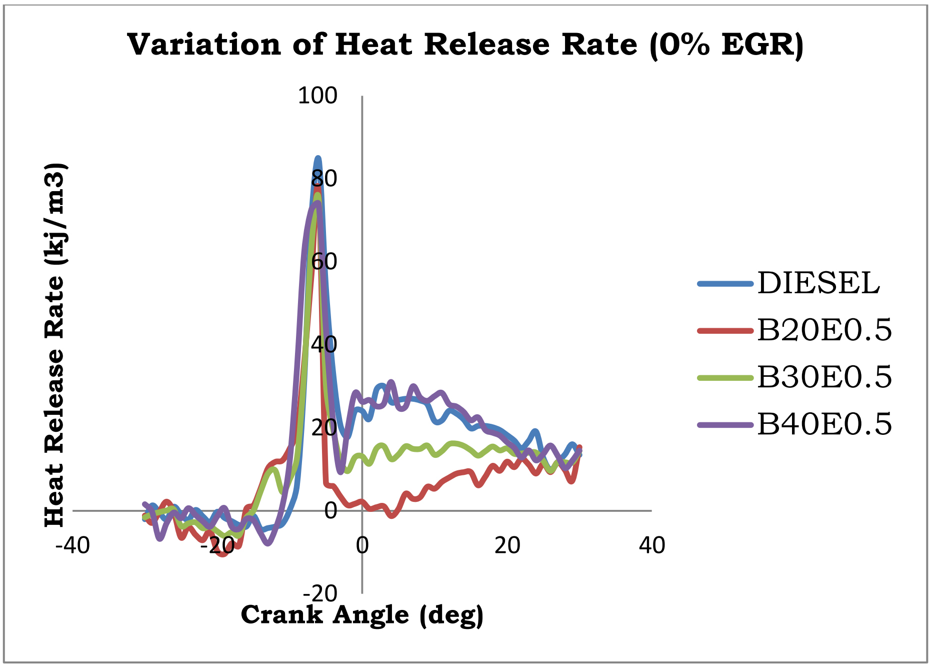


c) 20% EGR

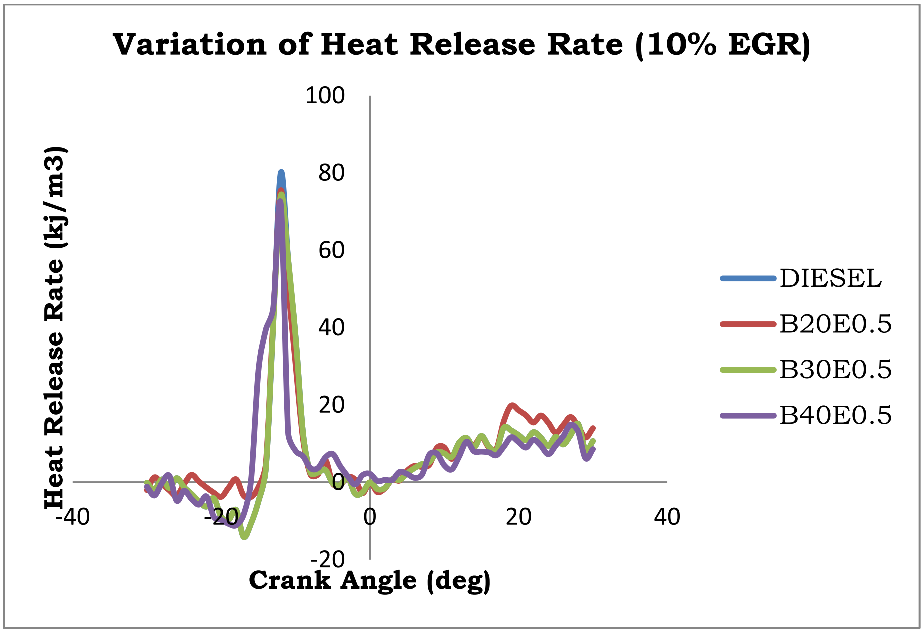


d) 30% EGR

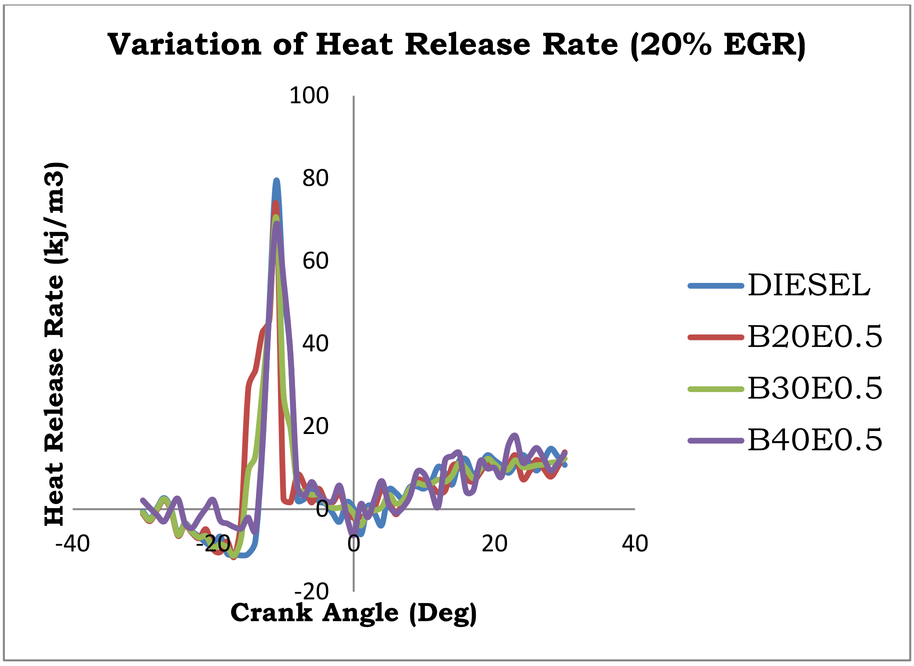
Figure 6. Variation of Cylinder Pressure with Crank Angle at Different EGR Rates (1% EHN) a) 0% EGR b) 10% EGR c)20% EGR d)30% EGR



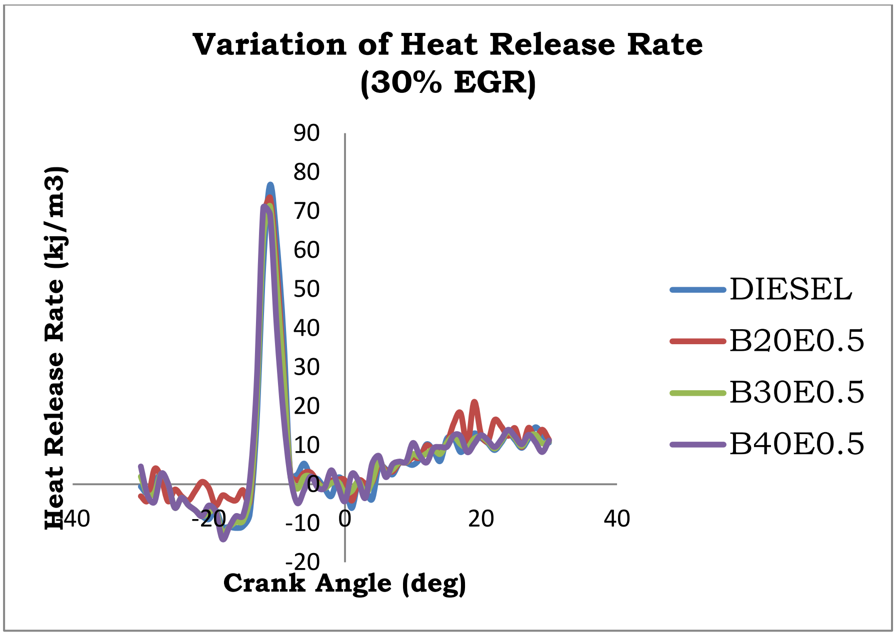
a) 0% EGR



b) 10% EGR

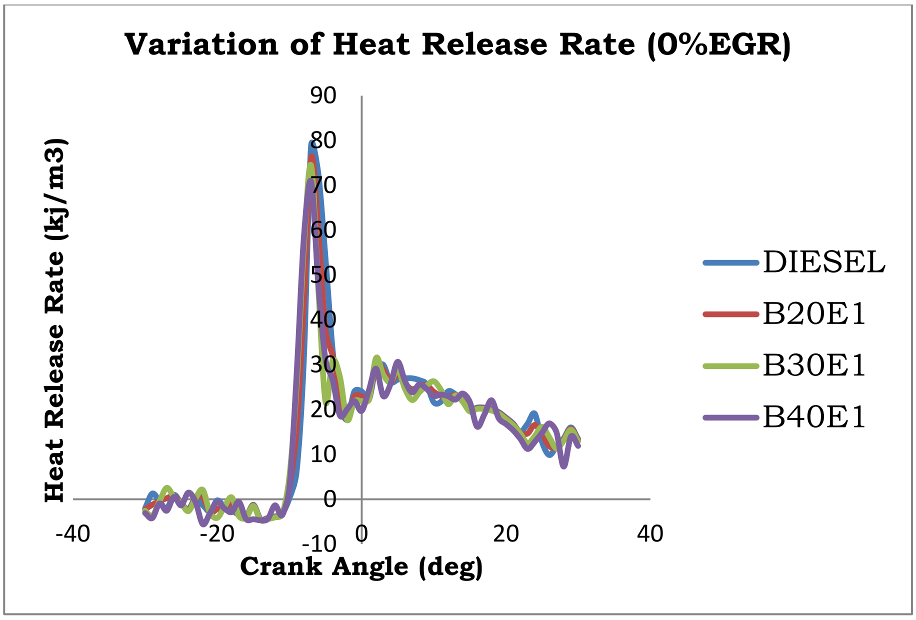


c) 20% EGR

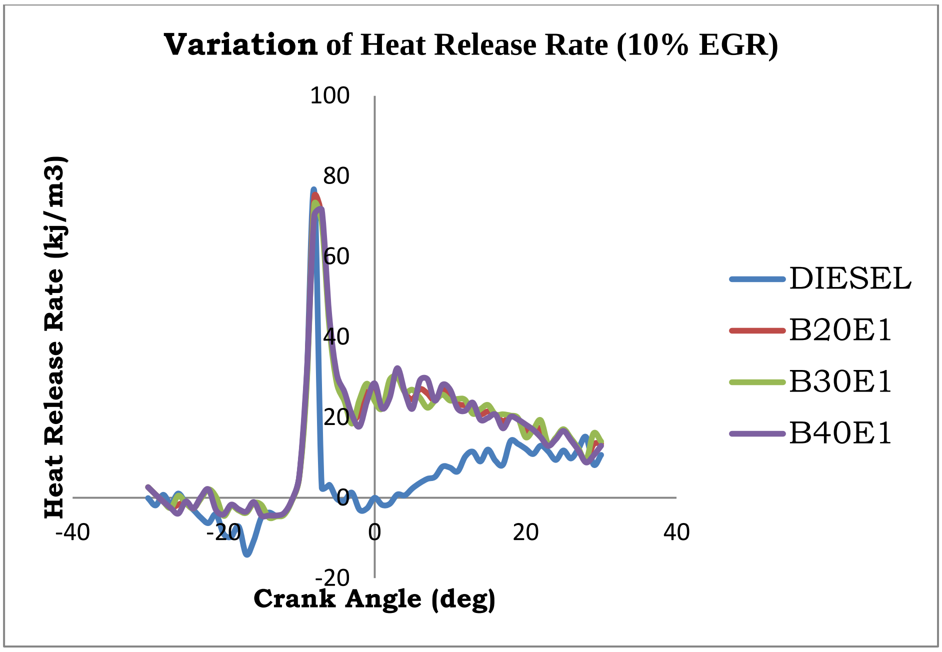


d) 30% EGR

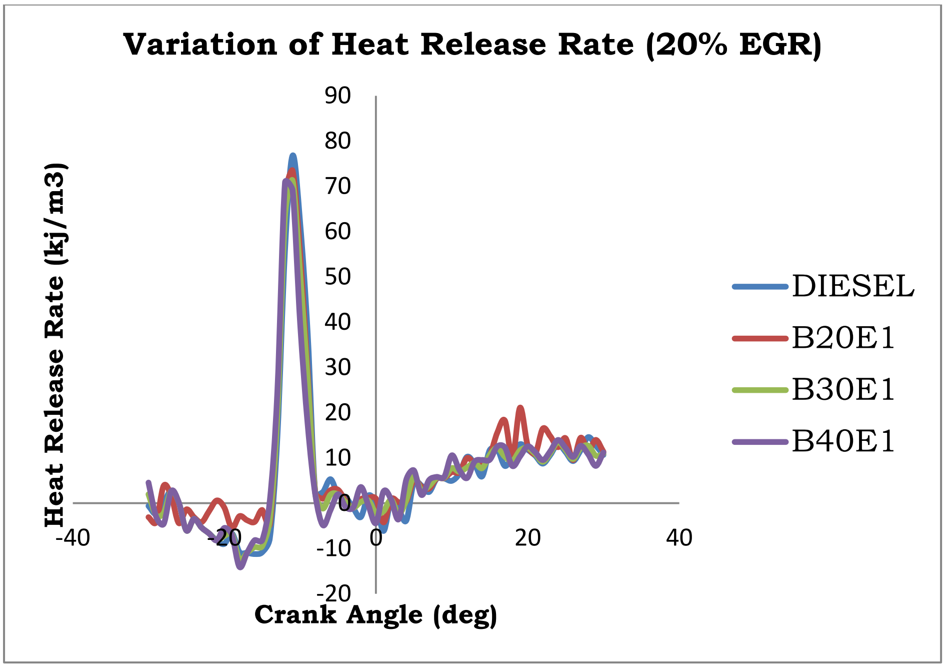
Figure 7. Variation of Heat Release Rate with Crank Angle at Different EGR Rates (0.5% EHN) a) 0% EGR b) 10% EGR c) 20% EGR d) 30% EGR



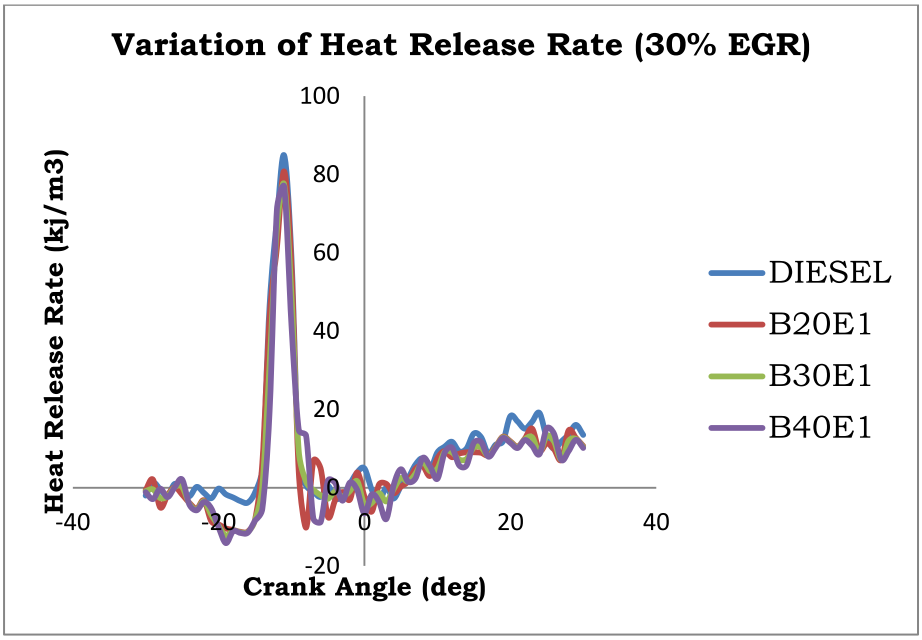
a) 0% EGR



b) 10% EGR



c) 20% EGR

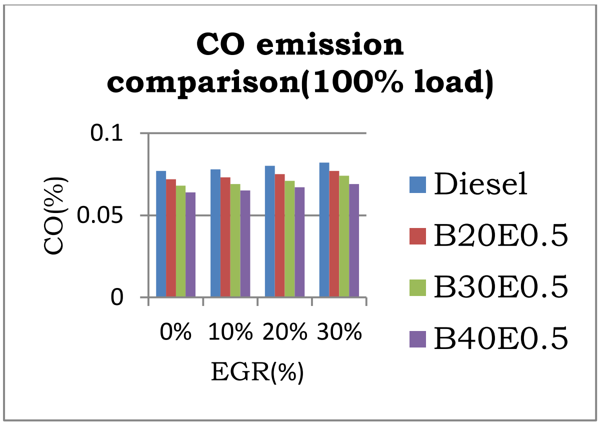


d) 30% EGR

Figure 8. Variation of Heat Release Rate with Crank Angle at Different EGR Rates (1% EHN) a) 0% EGR b) 10% EGR c)20% EGR d)30% EGR

4.3 Exhaust Emission Analysis

The experimental results of CO, NO_x, HC and smoke opacity emissions of diesel, blends of diesel-biodiesel with 0.5% and 1% EHN at various EGR rates such as 0%, 10%, 20% and 30% are shown graphically in Figures 9-12. Figure 9 presents the variation of the CO emissions with different EGR rates at 100% load. It is found that, CO emissions increase slightly with the increase in EGR percentage. However, CO emissions are reduced with increase in blend percentage and EHN as well when compared to that of diesel at a fixed EGR. At 30% EGR, CO emission of 0.069% is observed with B40E0.5, while 0.063% is observed with B40E1 when compared to 0.082% of pure diesel. The deficiency of oxygen with increase in the EGR percentage can be attributed to the increase in CO. However the excess oxygen content in bio-diesel can compensate for the oxygen deficient operation under EGR as a result of which biodiesel maintain the lower CO than diesel at a fixed EGR. Figure 10 presents the variation of the NO_x emissions of all the fuels with the different EGR rates. Figure shows that the combined effect of EGR and EHN reduces NO_x emissions significantly. At 30% EGR, biodiesel blend B40 with 0.5% EHN and 1% EHN demonstrate greater reductions in NO_x (i.e., 1091ppm, 1060 ppm respectively) when compared to that of diesel without EGR (1595 ppm) which are 35-40% less. The reason for greater reduction in NO_x with combined EGR and EHN is the reduction of combustion temperature as a result of the addition of exhaust gases to the intake air, which increases the amount of combustion accompanying gases which reduces the combustion temperature. Still higher EGR rates could reduce NO_x emissions by a large amount, which however is accompanied by a reduction in BTE and an increase in CO, HC and smoke emissions. Figure 11 shows that, the HC emissions increased slightly from 0% to 10% EGR for all fuels and thereafter this increase is marginal. It is observed that with increase in biodiesel, HC emissions are found decreasing. HC emissions of 24 ppm and 20 ppm are recorded with B40E0.5 and B40E1 when compared to 34.6 ppm for pure diesel. Figure 12 shows that, the smoke opacity increases significantly with increase in the percentage of biodiesel and increases further with increase in EGR. Furthermore, the addition of cetane improver also increases smoke opacity.



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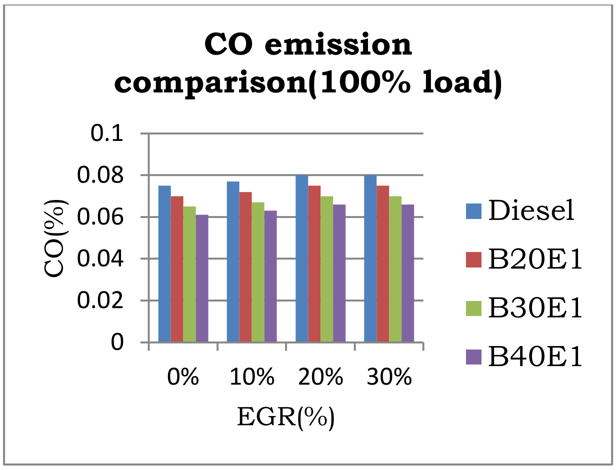
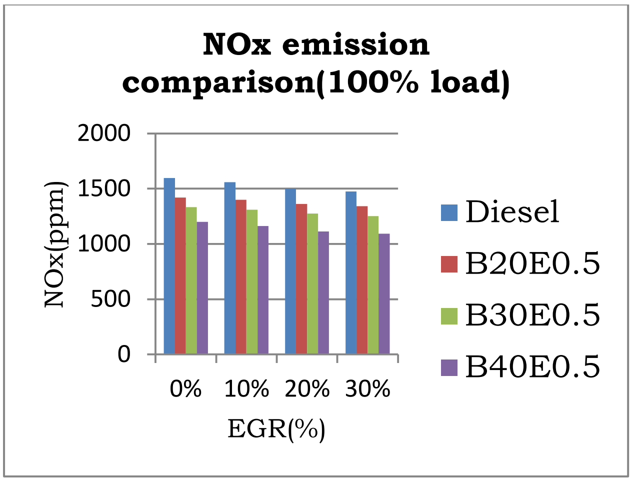


b)

Figure 9. Effect of Exhaust Gas Recirculation on CO Emissions (100% Load) a) 0.5% EHN b) 1% EHN



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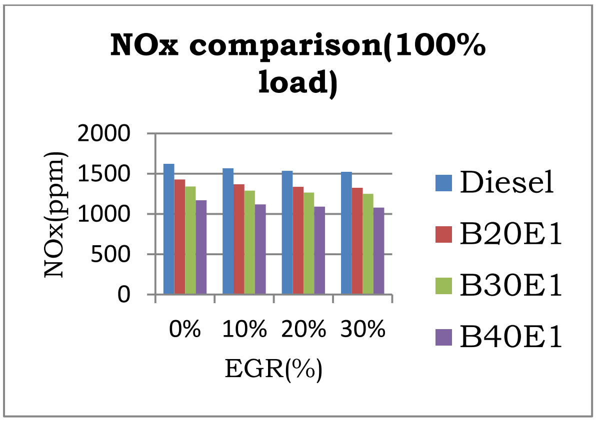
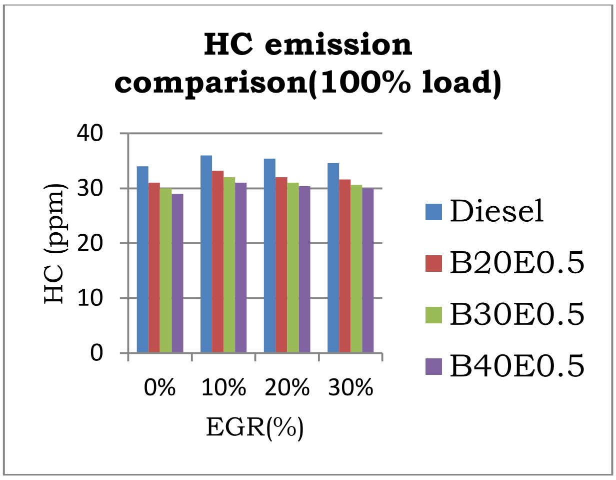
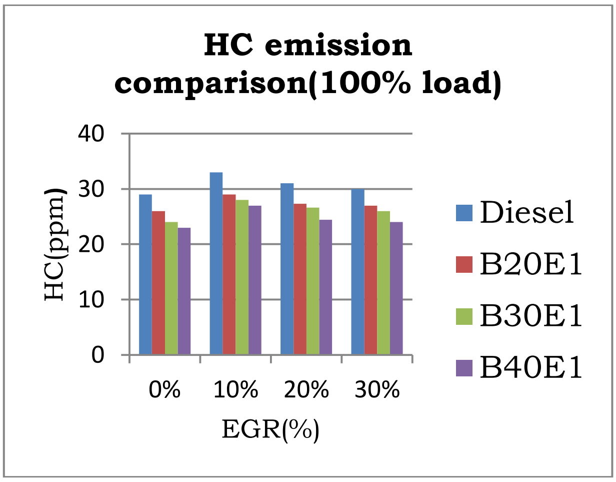


b)

Figure 10. Effect of Exhaust Gas Recirculation on NOx Emissions (100% Load) a) 0.5% EHN b) 1% EHN

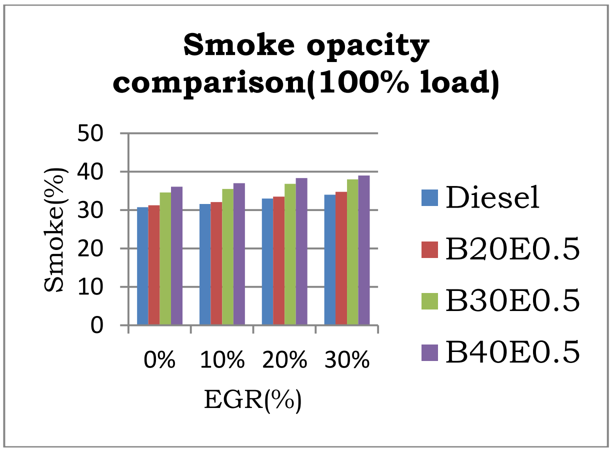


a)

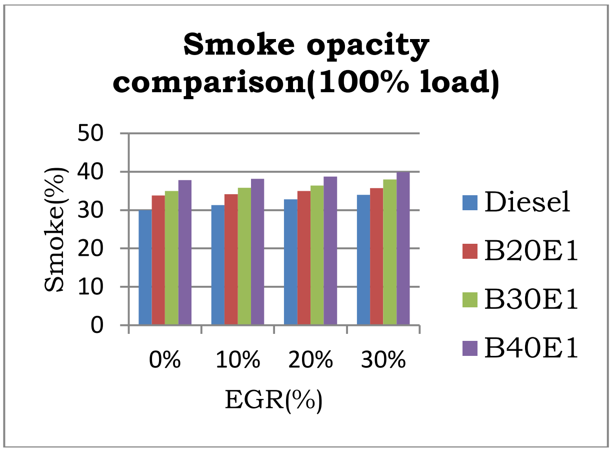


b)

Figure 11. Effect of Exhaust Gas Recirculation on HC Emissions (100% Load) a) 0.5% EHN b) 1% EHN



a)



b)

Figure 12. Effect of Exhaust Gas Recirculation on Smoke Opacity (100% Load) a) 0.5% EHN b) 1% EHN

5. Conclusion

The conclusions derived from the experimental investigation of diesel engine fueled with diesel as a baseline fuel and diesel-biodiesel blends with the combined effect of EHN and the EGR are summarized as follows:

1. The cetane improver and EGR (up to 20%) could increase BTE and decrease BSFC, maximum cylinder pressure and HRR slightly.

2. The CO emissions are found increasing with increase in the percentage of EGR. However, they are found decreasing with increase in percentage of biodiesel and EHN at a fixed EGR. The combined effect of EGR and cetane improver decreases NO_x emissions significantly.

4. The HC emissions are found to increase slightly with increase in the percentage of EGR up to around 10% and however this can be offset by the addition of EHN.

5. The smoke opacity increases with increase in the percentage of EGR and also increases with the increase in percentage of biodiesel. Smoke opacity is found to increase with increase in the percentage of cetane improver as well.

Finally, it is concluded that BSFC and smoke opacity increase with the increase in biodiesel percentage and furthermore, the rate of increase in BTE with the rate of increase in biodiesel blend percentage is less.

Hence, an optimum diesel-biodiesel blend is found as B20 and when EHN with not more than 0.5% by volume is added to it, better efficiency and emissions are observed at 20% EGR when compared to pure diesel operation.

References

[1] X. G. Wang, B. Zheng, Z. H. Huang, N. Zhang, Y. Z. Zhang and E. J. Hu , “Performance and emissions of a turbocharged, high-pressure common rail diesel engine operating on biodiesel/diesel blends”, Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, **(2010)**.

[2] R. M. Alagu and E. G. Sundaram, “Nitrogen oxide emission in biodiesel fuelled CI engines-A review”, Frontiers in Automobile and Mechanical Engineering, FAME-2010, IEEE Conference Publications, **(2010)**, pp.156–163.

[3] V. K Belagur and V. R Chitimini, “Effect of injector opening pressures on the performance, emission and combustion characteristics of DI diesel engine running on honge oil and diesel fuel blend,” Thermal Science, vol. 14, no. 4, **(2010)**, pp.1051–1061.

[4] M. M Roy, “Performance and emissions of a diesel engine fueled by diesel-biodiesel blends with special attention to exhaust odor,” Canadian Journal on Mechanical Sciences and Engineering, vol. 2, no. 1, **(2011)**, pp. 1–10.

[5] S. Oberweis and T. T Al-Shemmeri, “Effect of Biodiesel blending on emissions and efficiency in a stationary diesel engine”, International Conference on Renewable Energies and Power Quality (ICREPQ’10), **(2010)**.

[6] Y. X Li, N. B McLaughlin, B. S Patterson and S D Butt, “Fuel efficiency and exhaust emissions for biodiesel blends in an agricultural tractor,” Canadian Biosystems Engineering, vol. 2, no. 48, **(2006)**, pp. 15–22.

[7] 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”, Renewable and Sustainable Energy Reviews, vol. 21, **(2013)**, pp. 623–632.

[8] S. Kobori, T. Kamimoto and A. A. Aradi, “A study of ignition delay of diesel fuel sprays”, International Journal of Engine Research, vol. 1, no. 1, **(2000)**, pp. 29–39.

[9] W. Li, Y. Ren, X. B. Wang, H. Miao, D. M. Jiang and Z. H. Huang, “Combustion characteristics of a compression ignition engine fuelled with diesel—ethanol blends”, Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, vol. 222, no. 2, **(2008)**, pp. 265–274.

[10] Y. Akasaka, “Effects of oxygenated fuel and cetane improver on exhaust emission from heavy-duty DI diesel engines”, SAE Technical Paper no. 942023, **(1994)**.

[11] W. Yu, G. Chen and Z. H. Huang, “Influence of cetane number improver on performance and emissions of a common-rail diesel engine fueled with biodiesel-methanol blend”, Frontiers in Energy, vol. 5, no. 4, **(2011)**, pp. 412–418

[12] D. Jagadish, P. R. Kumar and K. M. Murthy, “The Effect of Supercharging on Performance and Emission Characteristics of C.I. Engine with Diesel-Ethanol-Ester Blends”, Thermal Science, vol. 15,no. 4, **(2011)**, pp. 1165-1174.

[13] Y. Ren, Z. H. Huang, D. M. Jiang, W. Li, B. Liu and X. B. Wang, “Effects of the addition of ethanol and cetane number improver on the combustion and emission characteristics of a compression ignition engine”, Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, vol. 222, no. 6, **(2008)**, pp. 1077–1088.

[14] M. Boot, P. Frijters, C. Luijten, B. Somers, R. Baert, A. Donkerbroek, R.J.H. Klein-Douwel and N. Dam, “Cyclic Oxygenates: A New Class of Second-Generation Bio fuels for Diesel Engines,” Energy & Fuels, vol. 23, no. 4, **(2009)**, pp. 1808–1817.

[15] N. Ladommatosa, S. Abdelhalima and H. Zhao, “Control of oxides of nitrogen from diesel engines using diluents while minimizing the impact on particulate pollutants”, Applied Thermal Engineering, vol. 18, no. 11, **(1998)**, pp. 963–980.

[16] P. V. Walke, N. V. Deshpande and R. G. Bodkhe, “Impact of Exhaust Gas Recirculation on the Performances of Diesel Engine”, Proceedings of the World Congress on Engineering, **(2008)**; London, U.K.

[17] M. Gomaa, A. J. Alimin and K. A. Kamarudin, “The effect of EGR rates on NO_x and smoke emissions of an IDI diesel engine fuelled with Jatropha biodiesel blends”, International Journal of Energy and Environment, vol. 2, no. 3, **(2011)**, pp. 477–490.

[18] V. Pradeep and R. P. Sharma, “Use of Hot EGR for NO_x control in a compression ignition engine fuelled with bio-diesel from Jatropha oil,” Renewable Energy, vol. 32, no. 7, **(2007)**, pp. 1136–1154.

[19] K. E. Lenox, R. M. Wagner, J. B. Green, J. B. Green Jr, J. M. Storey and C. S. Daw, “Extending exhaust gas recirculation limits in diesel engines”, A&WMA 93rd Annual Conference and Exposition, **(2000)**; Salt Lake City, UT.

[20] M. Y. E. Selim, “Effect of exhaust gas recirculation on some combustion characteristics of dual fuel engine,” Energy Conversion and Management, vol. 44, no. 5, **(2003)**, pp. 707–721.

[21] A.K. Agarwal, S. K. Singh, Shailendra Sinha and M. K. Shukla, “Effect of EGR on the exhaust gas temperature and exhaust opacity in compression ignition engines,” Sadhana, vol. 29, no. 3, **(2004)**, pp 275–284.

[22] H. Yokomura, S. Kohketsu and K. Mori, “EGR system in a turbocharged and intercooled heavy-duty diesel engine–expansion of EGR area with Venturi EGR system”, Technical Report No.15, Engine Research Department, Research & Dev Office, MFTBC, **(2003)**.

[23] Gurumoorthy, S. Hebbar and A. K. Bhat, “Control of NO_x from A DI Diesel Engine With Hot EGR And Ethanol Fumigation: An Experimental Investigation”, International Journal of Automotive Technology, vol. 14, no. 3, **(2013)**, pp. 45-53.

[24] K. Rajana and K. R. Senthilkumar, “Effect of exhaust gas recirculation (EGR) on the performance and emission characteristics of diesel engine with sunflower oil methyl ester”, Jordan Journal of Mechanical and Industrial Engineering (JJMIE), vol. 3, no. 4, **(2009)**, pp. 306–311.

[25] S. Saravanan, G. Nagarajan, R. Ramanujam and S. Sampath, “Controlling NO_x emission of crude rice bran oil blends for sustainable environment”, Clean—Soil, Air, Water. vol. 39, no. 6, **(2011)**, pp. 515–521.

[26] B. Abdalrahman, Fadhil, M. Mohammed, Dheyab, Kareem M. Ahmed and Marwa H.Yahya, “Biodiesel Production from Spent Fish Frying Oil Through Acid-Base Catalyzed Transesterification”, Pak. J. Anal. Environ. Chem, vol. 13, no. 1, **(2012)**, pp. 9-15.

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