International Journal of Mechanical Engineering
ISSN : 2277-7059 Volume 1 Issue 1
http://www.ijmejournal.com/ https://sites.google.com/site/journalijme/

PREDICTION ON REDUCTION OF EMISSION OF NOx IN DIESEL ENGINE USING BIO-DIESEL FUEL AND EGR (EXHAUST GAS RECIRCULATION) SYSTEM

POOJA GHODASARA[1], M.S. RATHORE[2]

[1] Lecturer in VVP Engineering College, Rajkot. Email:- pmghodasara@gmail.com
[2] Professor in Singhania University, Rajasthan. Email:- rathore.mohansingh@yahoo.com

ABSTRACT: Environmental degradation and depleting oil reserves are matters of concern round the globe. The search for energy independence and concern for cleaner environment have generated significant interest in biodiesel. It has shown that biodiesel fuelled engine produce less carbon monoxide, unburnt hydrocarbon and smoke emission compared to diesel fuel but higher NOx emission. EGR is as effective technique to reduce NOx from diesel engine as it lowers flame temperature and reduce oxygen concentration in combustion chamber. The objective of this research is to investigate the usage of biodiesel and EGR simultaneously in order to reduce the emissions of all regulated pollutants from diesel engine. For this a single cylinder, air cooled, constant speed direct injection diesel engine was used and EGR was developed and fitted in engine. Various emissions such as HC, NOx, CO and smoke opacity were measured. The engine performance parameters were calculated from measured data.

Keywords: Biodiesel, EGR, NOx, emissions, performance.

Introduction

Future economic growth shall crucially depend on long term availability of energy in increasing quantities from sources that are dependable, safe and environment friendly. Diesel engines are typically more efficient due to higher compression ratio and also find significant use in transportation sector, irrigation sector and small captive power plant engine because of its higher thermal efficiency and lower fuel consumption but it emits higher NOx which is one of the most undesirable pollutants. However technologies like EGR is essential to cater to the challenge posed by increasingly stringent environmental emission legislation.

Bio Diesel

Biodiesel are non toxic, renewable which is produced from plants, algae and animal fats. The following are the advantages

1) Biodiesel molecules are simple hydrocarbon chain, containing no sulphur or aromatic substance.
2) Biodiesel is an oxygenated fuel so it enhances the combustion process to be completed.
3) Biodiesel gives considerably lower emissions of particulate matters, carbon monoxide and hydrocarbons without any engine modification.
4) It has higher flash and fire point so it is safer to transport.
5) It has excellent lubricity.

Among all these advantages one major disadvantage of biodiesel is that it emits higher NOx which is one of the most undesirable pollutant.

EGR Technique

It is a well known technique to reduce NOx emission in which a part of exhaust gas is recirculated; it acts as diluents to the combustion mixture. Introduction of EGR is to
Reduce oxygen concentration
Increase specific heat of incoming charge which ultimately reduce peak combustion temperature
Resupply of unburned hydrocarbon (opportunity to reburn)
EGR ratio is calculated as
EGR %= Megr/ Mi * 100
Megr = Mass of recirculated gas/ Mass of total intake air of cylinder

Experimental Setup

A single cylinder, naturally aspirated four strokes, vertical air cooled engine is taken. Various parameters are measured by electric alternator type dynamometer used to measure brake power, tachometer to find rpm of engine, thermocouples to measure temperatures, AVL smoke meter to measure intensity of smoke and gas analyzer to measure various emissions like NOx, CO, HC etc.

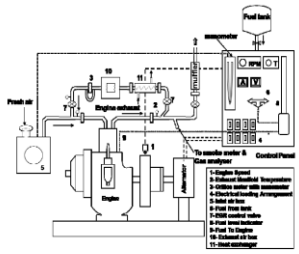

Fig 1. Schematic Line diagram of Test Rig

The objective of developing this experiment test set up is to investigate and demonstrate the effects of various EGR rates on engine performance and exhaust emission.

Specifications of the Diesel Engine

Make	Kirloskar
Model	DAF 10
Rated Brake Power (bhp/kw)	9.6 / 7
Rated Speed (rpm)	1500
Number of Cylinder	One
Bore X Stroke (mm)	17.5 : 1
Cooling System	Air Cooled (Radial Cooled)
Lubrication System	Forced Feed
Cubic Capacity	0.948 Lit
Starting Hand	Start with cranking handle
Inlet valve open (degree)	4.5 BTDC
Inlet valve close (degree)	35.5 ABDC
Exhaust valve open (degree)	35.5 BBDC
Exhaust valve close (degree)	4.5 ATDC

Results and Discussion

Initially with diesel engine a series of engine tests were carried out on medium capacity diesel engine at 1500 rpm and different EGR rates in order to show the effect of EGR on smoke opacity, NOx emission etc.

Exhaust Gas Temperature

The higher exhaust temperature with diesel engine without application of EGR is indicative of lower thermal efficiencies. At 10% EGR biodiesel gives lower exhaust temperature due to lower availability of oxygen and higher specific heat of intake air mixture.

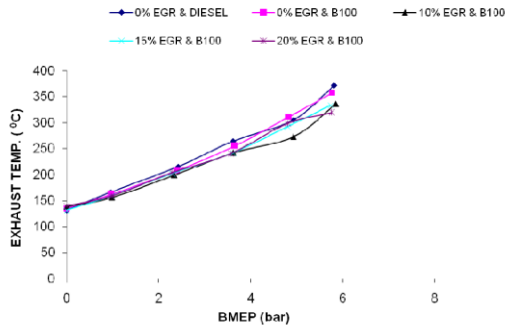

Fig 2. Variation of Exhaust gas temp. Vs BMEP for Biodiesel with different EGR rates

Brake Thermal Efficiency

The thermal efficiency is found increased with EGR at lower load due to reburning of HC that enter combustion chamber. At higher load with increase in EGR rate brake thermal efficiency decreases due to amount of fresh oxygen available for combustion get decreased due to replaced by exhaust gas.

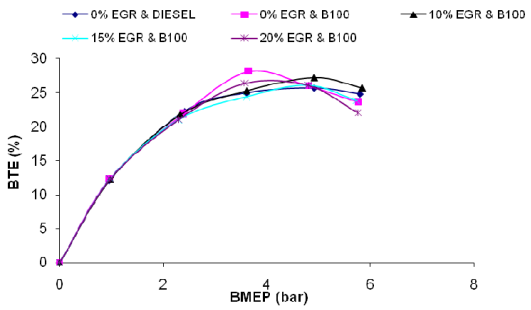

Fig 3. Variation of BTE Vs BMEP for Biodiesel with different EGR rates

NOx Emission

It is observed that with increase in EGR rates NOx emission also decreases due to lower flame temperature and oxygen concentration in combustion chamber. From graph it is observed that 20% EGR gives lowest NOx emission but there will be reduction in brake thermal efficiency and increase in smoke.

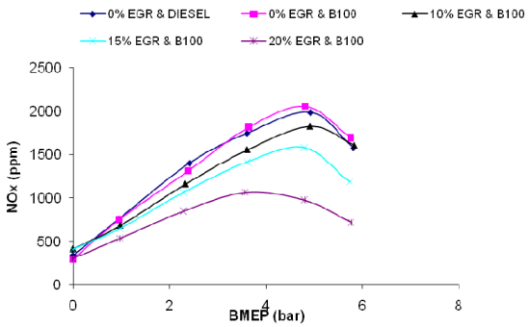

Fig 4. Variation of NOx Vs BMEP for Biodiesel with different EGR rates

HC Emission

It is observed HC emission increase with EGR and load. The HC emissions are lower in partial load but increase at higher engine load due to less oxygen available for combustion. It results in poor air- fuel mixture at different location inside combustion chamber and results in higher HC emission. 10% EGR is optimum for lower HC emission.

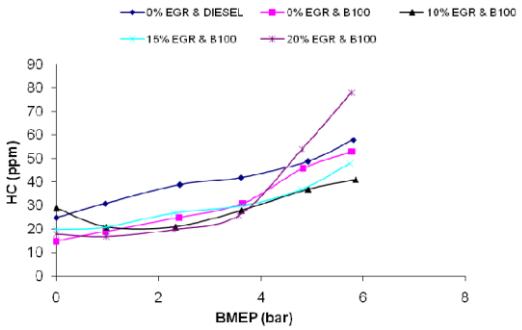

Fig 5. Variation of HC Vs BMEP for Biodiesel at different EGR rates

Smoke Opacity

Higher smoke opacity is observed when engine is operated with EGR compared to without EGR. Smoke opacity for biodiesel with EGR is noticed lower than diesel as it contains molecular oxygen responsible for better combustion. But it increases with increase in EGR rates.

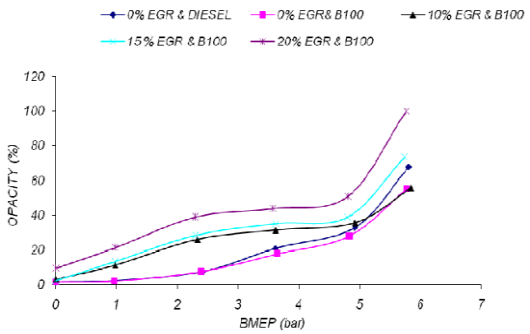

Fig 6. Variation of Opacity Vs BMEP for Biodiesel with different EGR rates

Conclusion

The effect of EGR rates along with biodiesel fuel on performance parameters and exhaust emission were investigated. The main conclusion are summarized as follow

1) Smoke opacity, HC emissions increases with increase in EGR rates
2) NOx emission decreases with increasing EGR rates

3) Brake thermal efficiency increases at low EGR rates at low load and then decrease with increase in EGR rates at higher load
4) From the experiment it can be suggested that 15% EGR is optimum for NOx reduction without significant penalty on brake thermal efficiency, HC and smoke opacity.

Future Scope

Though there are many advantages of EGR, however this technique still has some limitation in terms of engine durability, lubrication contamination etc. So another field of research is required to develop such a sophisticated EGR valve which could respond to dynamic mode of engine operation.

References

1. Mustafa Balat, Havva Balat, "A critical review of bio-diesel as a vehicular fuel" Energy Conversion and Management 49 pp 2727–2741, 2008.
2. Deepak Agarwal, Shailendra Sinha, Avinash Kumar Agarwal, "Experimental Investigation of control of NOx emissions in biodiesel-fueled compression Ignition engine" Renewable Energy 31 pp 2356-2369, 2006.
3. A. Salvatore, A. Maddaleena, "The effect of methyl ester of rapeseed oil on Combustion and emissions of D.I. diesel engines", SAE 932801; 1993.
4. C.Y. Chio, "Effect of bio-diesel blended fuels and multiple injections on D.I. Diesel engines", SAE 970218; 1997.
5. D. Ramesh, A. Sampathrajan. "Investigations on Performance and Emission Characteristics of Diesel Engine with Jatropha Biodiesel and Its Blends". Agricultural Engineering International: the CIGR e-journal, Manuscript EE 07 013. Vol. X., 2008.
6. M. P. Dorado, E. Ballesteros, J.M. Arnal, J. Go´mez, F.J. Lo´pez "Exhaust Emissions from a Diesel engine fueled with transesterified waste olive oil", Fuel 82 pp1311–1315, 2003.
7. A.S. Ramadhas, C. Muraleedharan, S. Jayaraj, "Performance and emission Evaluation of a diesel engine fueled with methyl esters of rubber seed oil" Renewable Energy 30 pp1789–1800, 2005.
8. Avinash Kumar Agrawal, Shrawan Kumar Singh, Shailendra Sinha, Mritunjay Kumar Shukla, "Effect of EGR on the exhaust gas temperature and exhaust Opacity in compression ignition engines", Sadhana Vol. 29, Part 3, pp. 275–284, 2004. 58
9. J.B. Heywood. Internal Combustion Engine Fundamentals. McGraw-Hill, New York, 1988; p. 864.
10. V. Pradeep, R.P. Sharma, "Use of HOT EGR for NOx control in a compression Ignition engine fuelled with bio-diesel from Jatropha oil", Renewable Energy 32 pp 1136–1154, 2007.
11. M. Ramavajjala, V. Palekar, R. "Slone, Fuel additives for in cylinder NOx Reduction from diesel engines", Report submitted to Califonia Energy Commission, July 1994.

12. A. Tsolakis, A. Megaritis, M.L. Wyszynski, K. Theinnoi, "Engine performance and emissions of a diesel engine operating on diesel-RME (rapeseed methyl ester) blends with EGR (exhaust gas recirculation)", energy 2007.
13. J.P. Szybist,A.L. Boehman, J.D. Taylor, R.L. McCormick, "Evaluation of formulation strategies to eliminate the biodiesel NOx effect", Fuel Processing Technology 86 pp 1109–1126, 2005.
14. M. Zheng, M.C. Mulenga, G.T. Reader, M. Wang, D.S-K Ting, J. Tjong, "Biodiesel engine performance and emissions in low temperature combustion", Fuel 87 pp 714–722, 2008.
15. D.T. Hountalas, G.C. Mavropoulos, K.B. Binder, "Effect of exhaust gas recirculation (EGR) temperature for various EGR rates on heavy duty DI diesel engine performance and emissions", Energy 33 pp 272–283, 2008.
16. A. Maiboom, X. Tauzia, J.F. He´ tet, "Experimental study of various effects of exhaust gas recirculation (EGR) on combustion and emissions of an automotive direct injection diesel engine", Energy 33 pp 22–34, 2008.
17. G.H. Abd-Alla, "Using exhaust gas recirculation in internal combustion engines: a review", Energy Conversion and Management 43pp 1027–1042, 2002.