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Effect of Exhaust Gas Recirculation on the Performances of Diesel Engine with Isobutonal Blends

A. Raj Kumar[1], G.Janardhana Raju [2] K.Hemachandra Reddy[3]
[1]Associate Professor, Guru Nanak Institute of Technical Campus (GNITC), Hyderabad. A.P
[2]Principal, Nalla Narsimha Reddy Engineering College Hyderabad. A.P
[3]Registar J.N.T.U Anantapur. . A.P.
Corresponding Email: alugo72@gmail.com

Abstract— **Exhaust Gas Recirculation (EGR) System means to use the Exhaust Gas coming from Exhaust Manifold to inlet manifold in order to reduce the emission of NO_X, which is particularly very harmful. Engine without EGR are more pollutant and uses more atmospheric air for combustion. By implementation of EGR system in engine, the partial exhaust gas is re-circulated again in engine. It is first cooled in EGR Cooler & then it is mixed with atmospheric air & then passed to Combustion Chamber. Fresh atmospheric air required is reduced & automatically pollutant (CO, CO2, HC, NOX etc.) is reduced. In the present work is to review the potential of exhaust gas recirculation (EGR) to reduce the exhaust emissions, particularly NO_X emissions, and to delimit the application range of this technique with different Isobutonal blends with diesel. In the present investigation brake mean effective pressure is highest at 5% of Isobutonal with 17.9225 of EGR and the brake thermal efficiency 22.65%. The Volumetric efficiency is almost same in all the cases and the brake specific fuel consumption is lower at 7% of Isobutonal with 22.65% of EGR. The system is very much Eco Friendly. Using Exhaust Gas Recirculation (EGR) Technique in engines, the emissions are very much controlled. This method is very reliable in terms of fuel consumption**

Keywords— Exhaust Gas Recirculation, NO_X emissions, AVL Gas Analyze, Infrared Thermometer.

I. Introduction

Introducing exhaust gas recirculation and is an effective approach to decrease, the nitrogen oxide emissions.[emissions]Introduction of EGR can significantly reduce the engine-out NOx emissions and can increase the ignition delay time; both of these are beneficial but a high rate of EGR causes a reduction in the in cylinder oxygen content therefore resulting in reduced combustion and increased formation of soot, carbon mono-oxide and un burnt hydrocarbons. Therefore the experiment is performed with a moderate EGR rate and its effects on the reduction of NOx emissions are studied.

An emission analysis of the fuel will be providing the answer to whether this mixture of fuel is cleaner than diesel or not. Further, to reduce emissions, we have chosen to provide exhaust gas recirculation in various percentages to reduce NOx emissions and to come up with a suitable and most optimum mix.

Researchers have used different additives to petrol and diesel fuels for efficiency and emission improvement. The addition of alcohol based fuels to petroleum fuels has been increasing due to advantages like better combustion and lower exhaust emissions. Gasoline with additives like ethanol and isobutanol increased the brake power volumetric and brake thermal efficiency and fuel consumption. Some researchers have used cetane improvers and some others have used additives in coated engines. Up to now Additives with coated engines improved efficiency, in addition to the increase in cylinder pressure. In this research we are checking the performance and exhaust emissions by addition of isobutanol exhaust gas recirculation technique.

The study will develop a comparison between the emission characteristics of diesel fuel to the Diesel- isobutanol blends. Emission standards are requirements that set specific limits to the amount of pollutants that can be released into the environment. Many emissions standards focus on regulating pollutants released by automobiles (motor cars) and other powered vehicles but they can also regulate emissions from industry, power plants, small equipment such as lawn mowers and diesel generators. An emission performance standard is a limit that sets thresholds above which a different type of emission control technology might be needed. While emission performance standards have been used to dictate limits for conventional pollutants such as oxides of nitrogen and oxides of sulphur (NOx and SOx), this regulatory technique may be used to regulate greenhouse gases particularly Carbon dioxide (CO_2).

In internal combustion (IC) engines, exhaust gas recirculation (EGR) is a nitrogen oxide (NO_X) emissions reduction technique used in petrol/gasoline and diesel engines. EGR works by re circulating a portion of an engine's exhaust gas back to the engine cylinders. .

N.k. Miller jothi et al., [1] studied the effect of Exhaust Gas Recirculation (EGR) on homogeneous charge ignition engine. A stationary four stroke, single cylinder, direct injection (DI) diesel engine capable of developing 3.7 kW at 1500 rpm was modified to operate in Homogeneous Charge Compression Ignition (HCCI) mode. In this work the diesel engine was operated on 100%. Liquefied Petroleum Gas (LPG). The LPG has a low cetane number (<3), therefore Diethyl ether (DEE) was added to the LPG for ignition purpose. DEE is an excellent ignition enhancer (cetane number >125) and has a low auto ignition temperature (160 ◦C). Experimental results showed that by EGR technique, at part loads the brake thermal efficiency increases by about 2.5% and at full load, NO concentration could be considerably reduced to about 68% as compared to LPG operation without EGR. However, higher EGR percentage affects the combustion rate and significant reduction in peak pressure at maximum load Higher carbon deposits were observed on the engine parts operating with EGR. Higher wear of piston rings was also observed for engine operated with EGR.

Deepak Agarwal et al., [2,3] investigate the effect of EGR on soot deposits, and wear of vital engine parts,especially piston rings, apart from performance and emissions in a two cylinder, air cooled, constant speed direct injection diesel engine, which is typically used in agricultural farm machinery and decentralized captive power generation. Such engines are normally not operated with EGR. The experiments were carried out to experimentally evaluate the performance and emissions for different EGR rates of the engine. Emissions of hydrocarbons (HC), NOX, carbon monoxide (CO), exhaust gas temperature, and smoke capacity of the exhaust gas etc. were measured. Performance parameters such as thermal efficiency, brake specific fuel consumption (BSFC) were calculated. Reductions in NOX and exhaust gas temperature were observed but emissions of particulate matter (PM), HC and CO were found to have increased with usage of EGR.

H.E.Saleh [4] studied Jojoba methyl ester (JME) has been used as a renewable fuel in numerous studies evaluating its potential use in diesel engines. These studies showed that this fuel is good gas oil substitute but an increase in the nitrogenous oxides emissions was observed at all operating conditions. The aim of this study mainly was to quantify the efficiency of exhaust gas recirculation (EGR) when using JME fuel in a fully instrumented, two-cylinder, naturally aspirated, four-stroke direct injection diesel engine. The tests were carried out in three sections. Firstly, the measured performance and exhaust emissions of the diesel engine operating with diesel fuel and JME at various speeds under full load are determined and compared. Secondly, tests were performed at constant speed with two loads to investigate the EGR effect on engine performance and exhaust emissions including nitrogenous oxides (NOX), carbon monoxide (CO), unburned hydrocarbons (HC) and exhaust gas temperatures. Thirdly, the effect of cooled EGR with high ratio at full load on engine performance and emissions was examined.

The results showed that EGR is an effective technique for reducing NOX emissions with JME fuel especially in light-duty diesel engines. With the application of the EGR method, the CO and HC concentration in the engine out emissions increased. For all operating conditions, a better trade-off between HC, CO and NOX emissions can be attained within a limited EGR rate of 5–15% with very little economy penalty.

II. Materials and Methods

Properties Of Fuels

ISO-BUTANOL: Isobutanol(2-methyl-1-propanol) is an organic compound with the formula (CH3)2CHCH2OH. This colorless, flammable liquid with a characteristic smell is mainly used as a solvent. Its isomers include n-butanol, 2-butanol, and tertbutanol, all of which are more important industrially. Isobutanol is produced by the carbonylation of propylene. Two methods are practiced industrially, hydroformylation is more common and generates a mixture of normal and isobutyraldehydes, which are hydrogenated to the alcohols and then separated. Reppe carbonylation is also practiced.

Isobutanol is also produced naturally during the fermentation of carbohydrates and may also be a byproduct of the decay process of organic matter. Isobutanol, along with other low molecular weight alcohols can also be produced by some engineered microorganisms such as E. coli and corynebacterium. A genetically engineered strain of the bacterium Clostridium cellulolyticum converted cellulose to isobutanol. Isobutanol can also be made directly from CO2 using cyanobacteria via photosynthesis and Ralstonia via electricity.

Properties of Iso-Butanol

2-methyl-1-propanol

Identity	
Synonyms	:2-methyl-1-propanol, Isobutanol, Isobutyl alcohol
Formula	: $C_4H_{10}O$
Molecular mass	: 74.12 g/mol
Physical properties	
Specific gravity	: 0.802 g/mL
Molar volume	: 92.5 mL/mol
Refractive index	: 1.396
Molecular refractive power	: 22.21 mL/mol
Liquid properties	
Melting point	: -108 °C
Boiling point	: 108 °C
Liquid density@20^0C	: $0.80 g/cm^3$
Flash point	: 28^0C (82 ^{0}F)
Freezing point	: < -90^0C (< -130^0F)
Vapour pressure	: 9 Torr
Surface tension	: 22.98 dyn/cm
Viscosity	: 3.96 cP
Critical temperature	: 275 °C
Critical pressure	: 42.4 atm
Solvent/Solute properties	
Dielectric constant	: 16.7
Solubility in water	: 9 % w/w
Solubility of water	: 15 % w/w
Thermo chemical data	
Specific heat capacity	: 53.0 cal/mol K

III. Experimental Details

The engine was a computerized single cylinder four stroke, naturally aspirated direct injection and water cooled diesel engine. The specifications of the test engine are given in below. In order to determine the engine torque, the shaft of the test engine was coupled to an electric dynamometer, which was loaded by an electric resistance. A strain load sensor was employed to determine the load on the dynamometer.

The engine speed was measured by an electromagnetic speed sensor installed on the dynamometer. The engine was equipped with an orifice meter connected to an inclined manometer to measure mass flow rate of the intake air. The temperatures of air inlet, cooling water engine inlet, cooling water engine outlet, water exchanger inlet, water exchanger outlet, exhaust gas engine outlet and exhaust gas exchanger outlet were measured by K type thermocouples.

The engine and the dynamometer were interfaced to a control panel which is connected to a computer. This engine was used for evaluating the performance characteristics of diesel blends and exhaust gas analysis with EGR technique. Engine Lab view Soft was used for recording the test parameters such as fuel flow rate, temperatures, air flow rate, load etc, and for calculating the engine performance characteristics such as brake power, brake thermal efficiency, brake specific fuel consumption and volumetric efficiency.

ENGINE SPECIFICATIONS

TYPE: 4 - STROKE, 1 - CYLINDER DIESEL ENGINE
MAKE : KIRLOSKAR A V – 1
POWER: 3.7 KW, 1500 RPM
BORE & STROKE: 80MM x 110 MM
COMPRESSION RATIO: 16.5:1 VARIABLE UPTO 20
CYLINDER CAPACITY: 553 CC
DYNAMOMETER: ELECTRICAL AC ALTERNATOR
CYLINDER PRESSURE: BY PIEZO SENSOR,
RANGE 200 PSI
ORFICE DIAMETR: 20 MM

Fig: 1 Experimental Set up

Engine performance parameters that are considered are: thermal efficiency, volumetric efficiency and air-excess ratio. Thermal efficiency is investigated because it is a direct measure for fuel efficiency. Volumetric efficiency is a measure for power output and air-excess ratio could influence particulate emissions and HC emissions. Another, very practical reason is that these could be tested with the available equipment. Emissions are not measured in this study because there was no possibility of measuring these. To validate the predictions an experimental set-up is built and experiments are carried out. The experimental set-up contains a of small diesel generator set, which can run on Isobutanol blends with diesel oil, and exhaust gas at different percentage is added with the intake air.

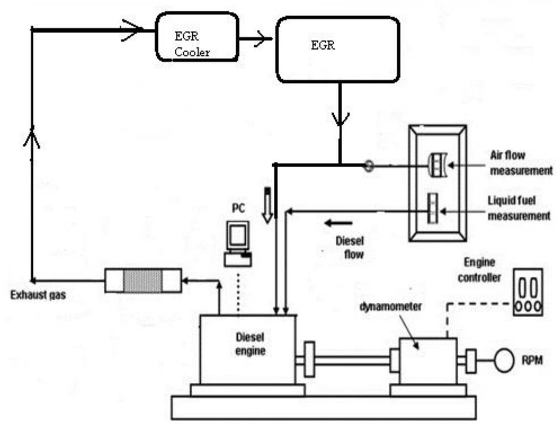

Fig: 2 Experimental Set up with line diagram

The engine was run at a constant speed of 1500 rpm, Injector pressure 220 (bar), compression ratio 16.5:1.Engine loads were adjusted by eddy current dynamometer. Three blending fuels were prepared in volume and employed in the experiments along with pure diesel fuel. The blends were 95% diesel fuel and 5% isobutanol (ISB5), 93% diesel fuel and 7% isobutanol (ISB7), 90% diesel fuel and 10% isobutanol (ISB10). All tests were performed under steady state conditions. First test was conducted with pure diesel fuel to obtain the base data of the engine.

The first stage of experiments was performed with pure diesel at different loads from no-load to full load and at constant speed. After that, in the second stage of experiments was conducted diesel with Isobutonal blends (at different compositions) at different loads from no-load to full load and at constant speed.

The third stage of experiments was conducted using blends of diesel (5% isobutanol) with exhaust gas recirculation (at different compositions) at different loads from no-load to full load and at constant speed. Engine Lab view Soft was used for recording the test parameters such as fuel flow rate, temperatures, air flow rate, load etc, and for calculating the engine performance characteristics such as, brake thermal efficiency, brake specific fuel consumption and volumetric efficiency. The ratio of experimental values of the engine performance parameters obtained compared with pure diesel values in graphic mode.

IV. Results and discussion

In the present work diesel is considered as reference fuel, and experiments were conducted with different blends of Isobutonol and exhaust gas recirculation combinations. The results were compared with the reference fuel and test fuel.

Brake Mean Effective Pressure Vs EGR% at various Isobutonal Percentage:

From the graph 3 it is inferred that the brake mean effective pressure is high at 5% of Isobutonal and 95% of diesel with 17% of Exhaust gas recirculation. When pure diesel and Exhaust gas recirculation is used the brake mean effective pressure decreases up to certain extent and increases.

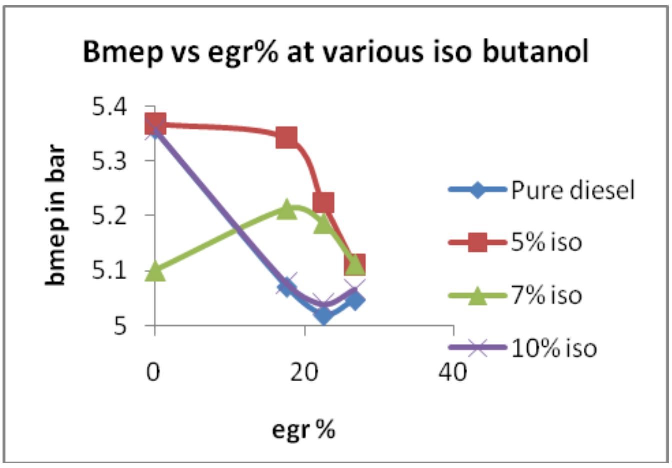

Fig. 3 EGRVs Brake mean Effective Pressure

BRAKE THERMAL EFFICIENCY VS EGR%:

From the graph 4 it is inferred that the brake thermal efficiency is highest at 5% of Isobutonal with 22% of EGR is 28.32% and lowest at 7% of Isobutonal with the same percentage of EGR.

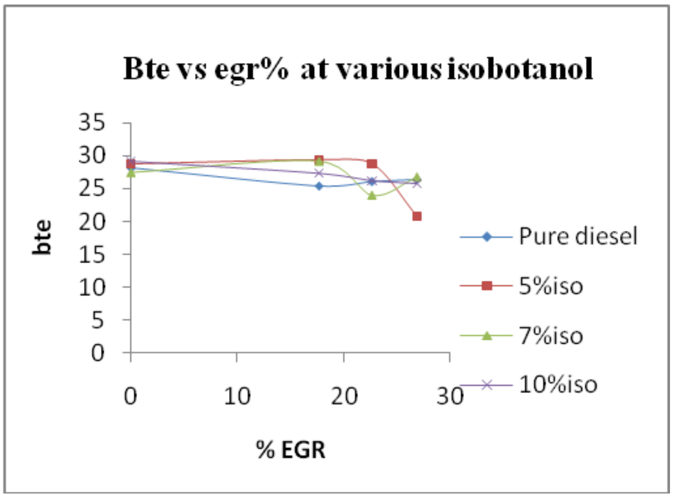

Fig. 4 Brake thermal efficiency Vs EGR

BRAKE SPECIFIC FUEL CONSUMPTION VS EGR%:

From the graph 5 it is inferred that the brake specific fuel consumption is low for 5% of isob utonal at 22.65% of EGR and high at the same EGR 7% of isobutonal and pure diesel falls in between these two for the same EGR.

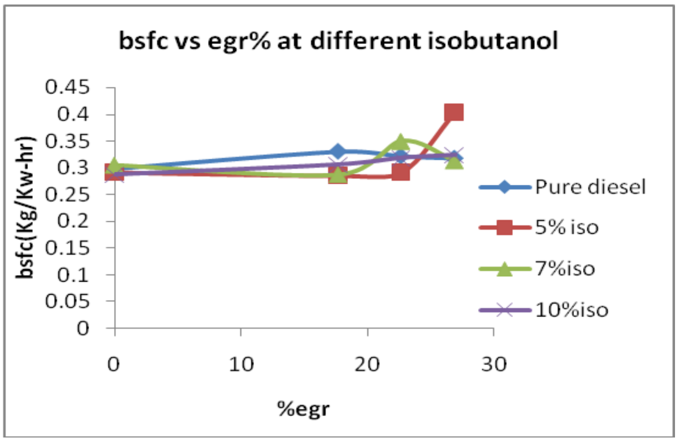

Fig. 5 Brake specific fuel consumption Vs EGR

Volumetric Efficiency VS EGR%:

From the graph 6 it is inferred that the volumetric efficiency for all the Isobutonal blends for different EGR ratio is same.

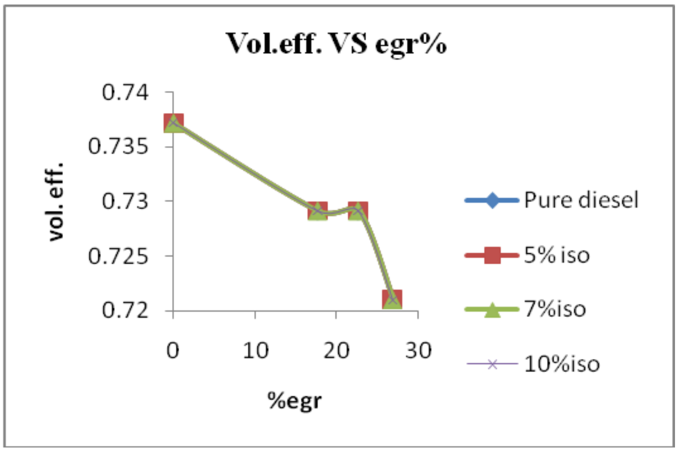

Fig. 6 Volumetric Efficiency Vs EGR

NOx Emissions VS EGR%:

From the above graph 7 it is inferred that the Nox Emissions were increased when pure diesel at different percentages of EGR, and is high at 28.6% EGR and low at 22.6%.Nox emissions are low at 5% and 7% of Isobutonal with 22.6% of EGR. With increasing the percentage of Isobutonal and EGR the Nox emissions are observed that they increase slightly when compared at 5% and 7% of Isobutonal.

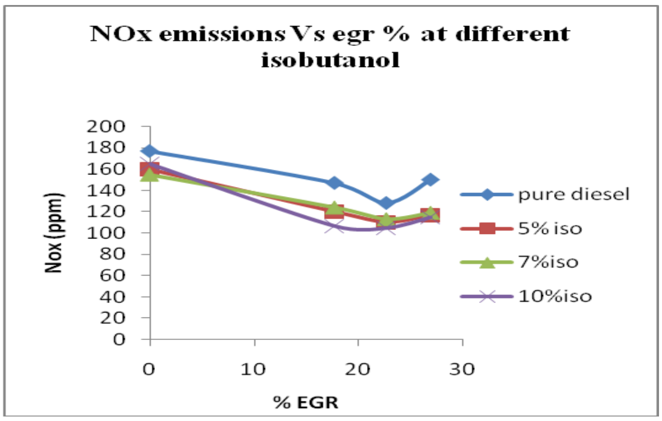

Fig. 7 Nox Emissions Vs % EGR

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CO Emissions VS EGR%:

From the above graph 8 it is inferred that the Hydro Carbon emissions are minimum in pure diesel at 17.5% of EGR, and are increasing with increase of EGR. Hydro Carbon emissions are high at 10% of Isobutonal blend with diesel. By decreasing the Isobutonal percentage HC emissions decreases for the same EGR.

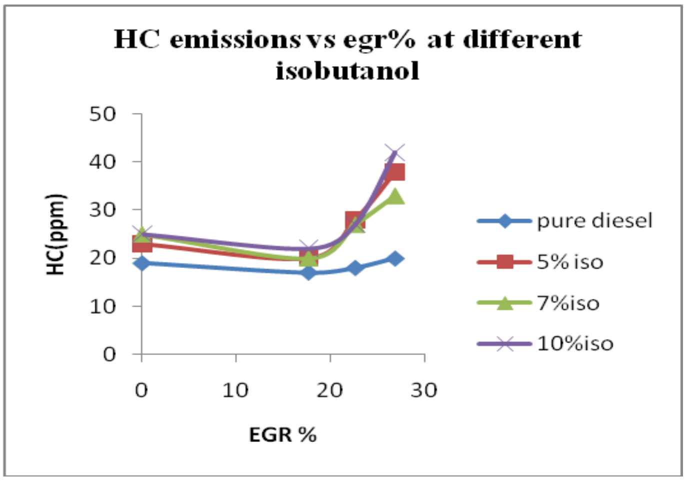

Fig. 8 HC Emissions Vs % EGR

CO Emissions VS EGR%:

From the above graph 9 it is inferred that the Carbon monoxide emissions are low at 5% of Isobutonal at 22.5% of EGR when compared with pure diesel. By increasing the percentage of Isobutonal the carbon monoxide increases for the same EGR.

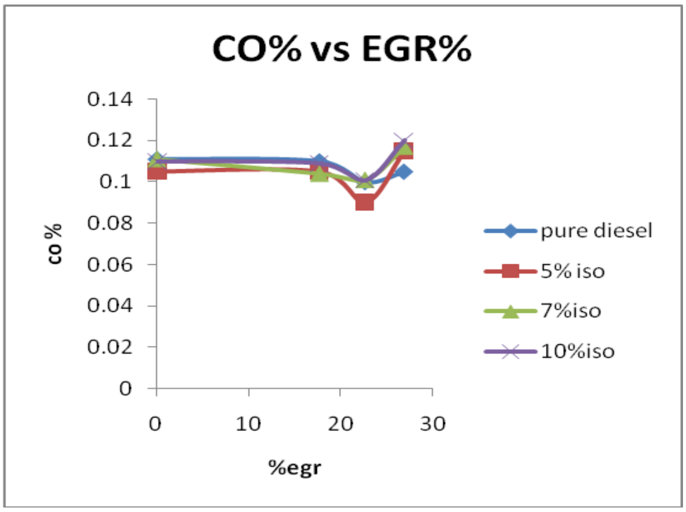

Fig. 9 CO Emissions Vs % EGR

V. Conclusions

The objective of this present work is to review the potential of exhaust gas recirculation (EGR) to reduce the exhaust emissions, particularly NO_X emissions, and to delimit the application range of this technique with different Isobutonal blends with diesel. In the present investigation brake mean effective pressure is highest at 5% of Isobutonal with 17.9225 of EGR and the brake thermal efficiency 22.65%. The Volumetric efficiency is almost same in all the cases and the brake specific fuel consumption is lower at 7% of Isobutonal with 22.65% of EGR. The system is very much Eco Friendly.

The Nox Emissions were increased when pure diesel at different percentages of EGR, and is high at 28.6% EGR and low at 22.6%.Nox emissions are low at 5% and 7% of Isobutonal with 22.6% of EGR. With increasing the percentage of Isobutonal and EGR the Nox emissions are observed that they increase slightly when compared at 5% and 7% of Isobutonal. The Carbon monoxide emissions are low at 5% of Isobutonal at 22.5% of EGR when compared with pure diesel. By increasing the percentage of Isobutonal the carbon monoxide increases for the same EGR. The Hydro Carbon emissions are minimum in pure diesel at 17.5% of EGR, and are increasing with increase of EGR. Hydro Carbon emissions are high at 10% of Isobutonal blend with diesel same EGR.

References

i. *N.K. Miller Jothi, G. Nagarajan, S. Renganarayanan; LPG fueled diesel engine using diethyl ether with exhaust gas recirculation, International Journal of Thermal Sciences 47 (2008) 450–457.*

ii. *Deepak Agarwal , Shrawan Kumar singh,Avinash Kumar Agarwal; Effect of Exhaust Gas Recirculation (EGR) on performance, emissions, deposits and durability of a constant speed compression ignition engine, Applied Energy 88 (2011) 2900–2907.*

iii. *Deeapak 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.*

iv. *H.E. Saleh; Effect of exhaust gas recirculation on diesel engine nitrogen oxide reduction operating with jojoba methyl ester, Renewable Energy 34 (2009) 2178–2186.*