International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 06, June-2015

Investigations into CI Diesel Engine Performance and Emission Characteristics using Biodiesel with EGR Technique

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Abstract:- **Energy in the form of fossil fuels have been a matter of great concern for human consumption. There is a need to increase energy supplies to meet basic needs and to do it in a way that promotes sustainable development. Now days, the stringent regulations have been implemented on emission control. Apart from this, it is learnt that the fossil fuels are going to be depleted in near future. In order to meet the forthcoming demand of fossil fuels, there is a need to search alternate fuels like biodiesel, hydrogen, CNG etc. Many problems can be sort out by using biodiesel blends like carbon dioxide, carbon monoxide and hydro carbon emissions. Along with this fuel ignition quality is increased as biodiesel has high cetane number than diesel. In this work an attempt is to be made to use biodiesels in place of diesel fuels. It is known that the most of the biodiesels are oxygenated fuels. Due to the presence of excess oxygen in biodiesels may lead to more emission of NOx as compared to conventional fuel engine. Further the high temperature combustion may be takes place with this sort of fuels. Hence to reduce NOx emissions and to have low temperature combustion processes the exhaust gas recirculation process may be implemented in this work.experimental investigation is done under different loading circumstances in a single cylinder four stroke, direct injected, water-cooled, single naturally aspirated kirloskar diesel engine is used for investigation.**

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

INTRODUCTION

Petroleum fuel is a non-renewable source of energy. The petroleum reserves have been depleting and there is rise in petroleum prices. But there is an enormous upsurge in number of vehicles each year which has regenerated interest in alternative fuels. The biodiesel has emerged as alternative for diesel fuel due to its renewable nature, better gnition quality, comparable energy content, higher flash point. Biodiesel refers to a vegetable oil or animal fat-based diesel fuel consisting long chain of esters. It is made by chemically reacting the lipids with an alcohol producing fatty acid esters. A lot of researches have been conducted on internal combustion engines using biodiesel fuel and it shows that the engines produce less carbon monoxide, smoke emissions and unburned hydrocarbon compared to diesel fuel but higher NOx emission. Diesel engine combustion yields large amounts of NOx because of high flame temperatures in presence of ample oxygen and nitrogen in the combustion chamber. Upsurged environmental concerns and tougher emission norms have led to the development of advanced engine technologies to reduce NOx. Exhaust Gas Recirculation is one of the most efficient methods to decrease NOx emission in diesel engine.

EGR TECHNIQUE

Exhaust Gas Recirculation (EGR) is one of the widely used technique to reduce NO_x emission gases. This technique involves mixing of inlet air with controllable amount of exhaust gases.A valve is usually used to control the flow of gas based on requirement, and the valve may be closed completely if necessary.Recirculating of burnt gas (which takes no further part in combustion) into oxygen rich air reduces the proportion of the cylinder contents available for combustion.This leads to correspondingly lower heat release and peak cylinder temperature, and reduces the formation of NO_x as fresh air charge is decreased.

EXPERIMENTAL TEST SETUP:

A four stroke, direct injected, water-cooled, single cylinder, naturally aspirated diesel engine is used for investigation. The base engine specifications are presented in table.

Number of cylinders	1
Number of strokes	4
Fuel	diesel
Rated Power	5.2 KW/7 hp @ 1500 RPM
Cylinder bore	87.5mm
Stroke Length	110mm
Compression Ratio	17.5:1
Dynamometer arm length	185mm
Dynamometer Type	Eddy Current
Type of cooling	water cooled

- The experiments were conducted at six load levels, viz. 2kg, 4kg, 6kg, 8kg, 10kg, 12kg using Eddy current dynamometer at different speeds.
- The mass flow rate of air is measured using a manometer setup by Air Box method. Fuel flow rate is measured by a gravimetric type Fuel consumption meter.
- Pressure and temperature sensors are mounted at important locations in engine exhaust, water inlet, water outlet, air intake, lube oil for online recording of pressure and temperature values using a Digital Dyno Controller unit and Data Acquisition System.
- Emission characteristics such as Carbon monoxide (CO), Hydro carbon (HC) and carbon dioxide (CO_2) were measured by using exhaust gas analyzer.
- All the readings were carried out using ARAI–EDACS controller setup and the readings were stored in a personal computer automatically.

- The Schematic of experimental setup is shown in Figure1.

Figure1: Computerized I C Engine setup.

All the exhaust gases were measured by using exhaust gas analyzer as shown in Figure 2.

Figure2: Multiple Gas Analyzer

MEASUREMENT METHOD:

The performance and emission characteristics of an engine can be measured with the help of fuel consumption measuring unit, Volt meter, Ammeter, Tachometer, Thermocouples and emission measurement. Starting from no load observation was recorded at 20%, 40%, 60%, 80% and 100% of rated load.

Exhaust emission analysis*:* For measuring smoke opacity and emission gases, exhaust gas analyzer was used for measuring unburnt Hydrocarbon, Carbon Dioxide, Carbon Monoxide and Nitrogen Oxide.

Measurement of gas recalculated air: The quantity of EGR is to be measured and controlled accurately bypass for exhaust gas is provided along with manually controlled EGR valve and orifice meter is designed and installed to measure volumetric flow rate of EGR.

RESULTS AND DISCUSSIONS

The experimental investigations are carried out using the above said alternative fuel oil and Diesel on the test engine with Exhaust Gas recirculation. The detailed analyses of these results are discussed in this section in the form of graphs. The salient features of these graphs would be outlined in the following sections.

ENGINE PERFORMANCE AND EMISSIONS FOR DIESEL AND BIODIESEL WITH DIFFERENT RATES OF EGR

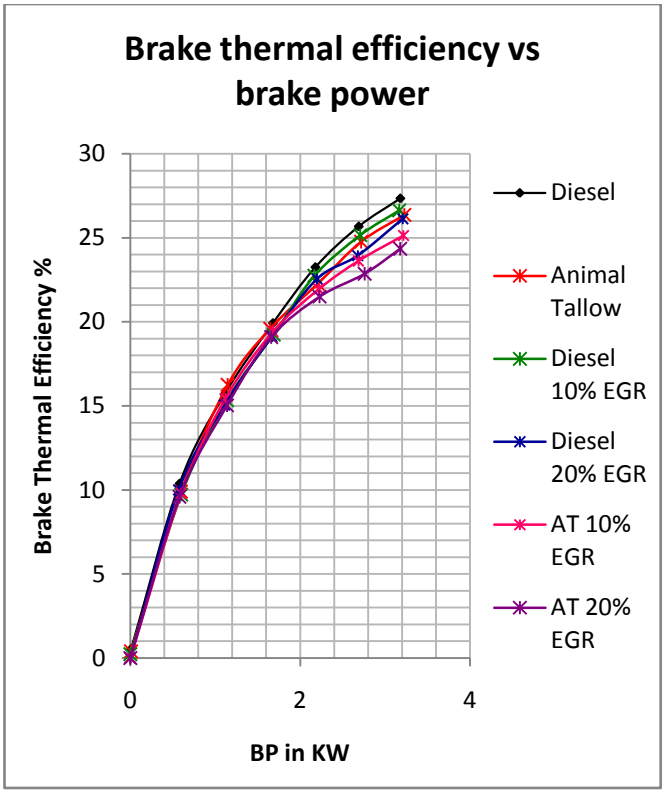

Figure 3: Variation Of Brake Thermal Efficiency With Brake Power

Figure3.Shows the variation of Brake Thermal efficiency of the engine with respect to Brake power for Diesel and Animal Tallow Biodiesel for 10% EGR and 20% EGR. From the above variation it can be concluded that the Brake thermal efficiency increases with increase in brake power which is proportional to load for Diesel and Biodiesel used in this project work with 10% EGR and 20% EGR .From the above curves the Brake thermal efficiency decreases with increase in % of EGR in this project work. The maximum Brake thermal efficiency obtained for Diesel is 27.35% at 12 kg load in this project work.

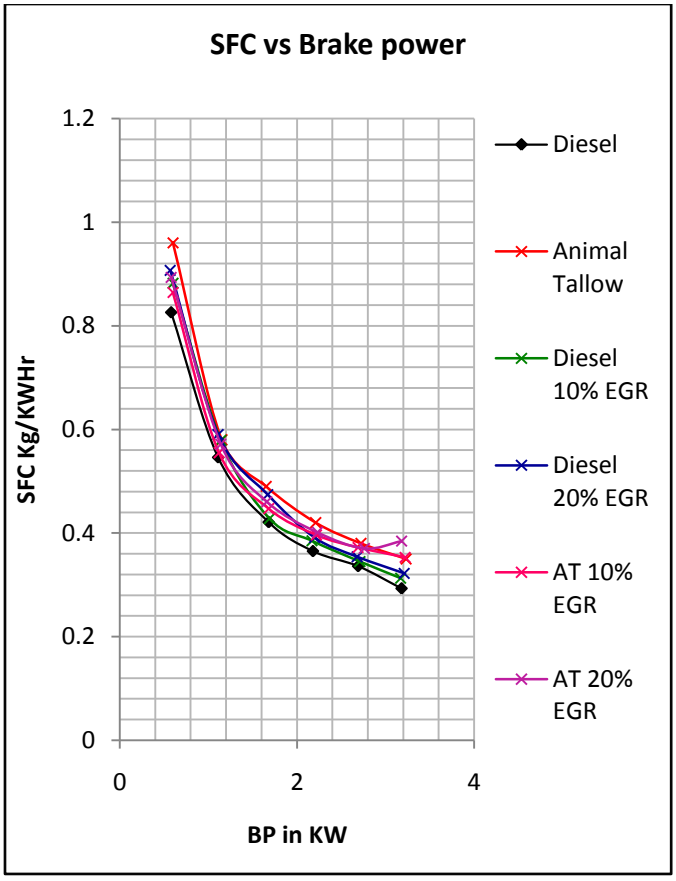

Figure 4: Variation Of Specific Fuel Consumption With Brake Power

Figure 4 shows the variation of Specific fuel consumption of the engine with respect to Brake power for Diesel and Animal Tallow Biodiesel with 10% EGR and 20% EGR. From the above variation it can be concluded that the Specific Fuel Consumption decreases with increase in brake power which is proportional to load for both Diesel and Biodiesel. The Specific Fuel Consumption with respect to brake power at 20% EGRs slightly higher in comparison with Specific Fuel Consumption with respect to brake power at 10% EGR for both Diesel and Animal tallow biodiesel used in this project work.

The Specific Fuel Consumption is lower for Diesel when compared with that of Animal tallow biodiesel at both 10% EGR and 20% EGR respectively. The minimum Specific Fuel Consumption obtained for Diesel is 0.297kg/hr in this project work.

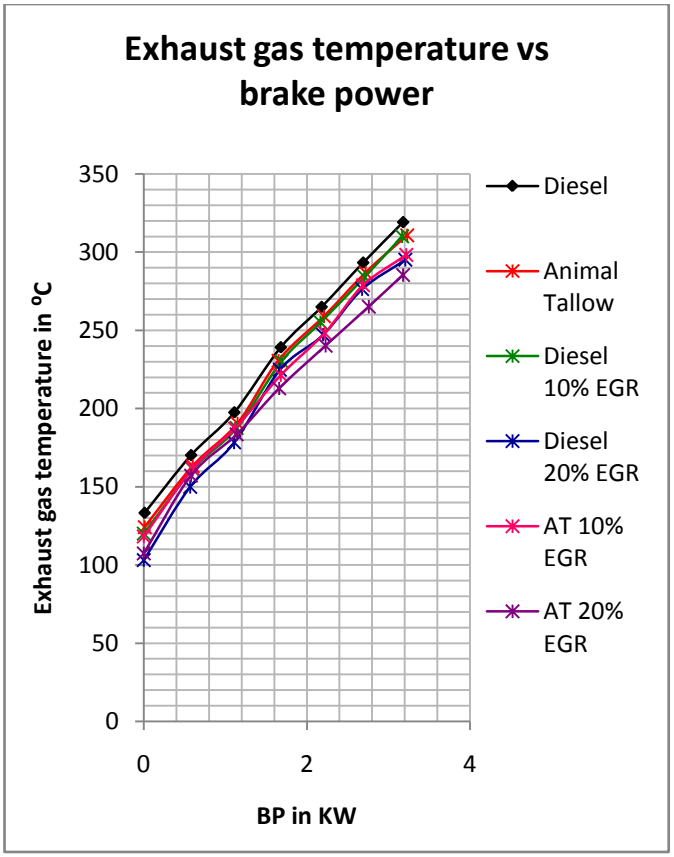

Figure 5: Variation Of Exhaust Gas Temperature With Brake Power

Figure 5Shows the variation of Exhaust gas temperature of the engine with respect to brake power for Diesel and animal tallow biodiesel for all rates of EGR. The Exhaust gas temperature increases with increase in load. The Exhaust gas temperature for diesel is higher compared with animal tallow biodiesel. The Exhaust gas temperature decreases with increase in rate of EGR for both Diesel and Animal Tallow Biodiesel used in this project.

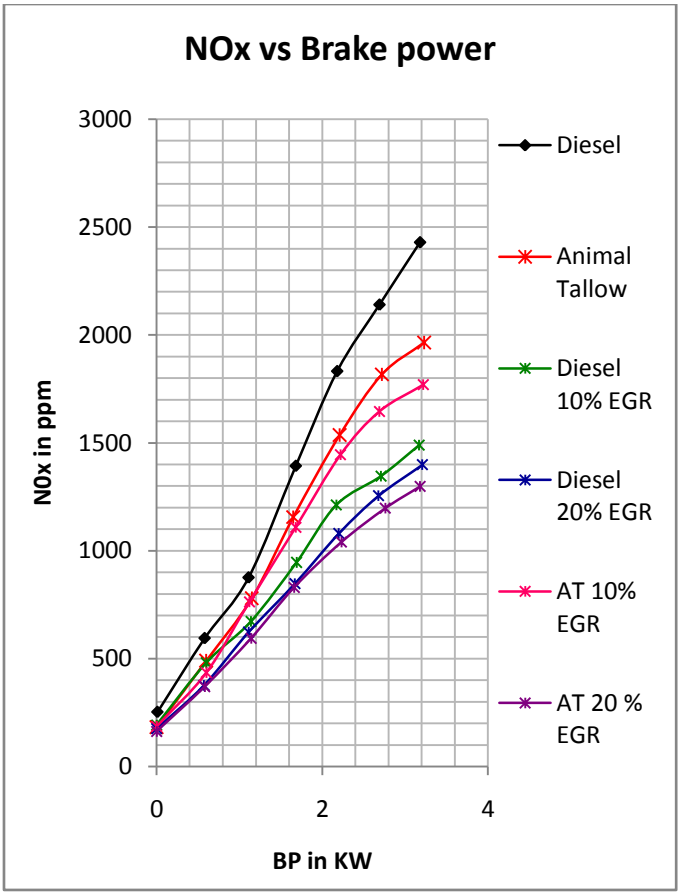

Figure 6: Variation OfNo_x Emission With Brake Power

Figure 6 shows the variation of oxides of Nitrogen emissions from the engine with respect to Brake power for Diesel and Animal Tallow Biodiesel at 10% EGR and 20% EGR. From the above variation it can be concluded that the oxides of Nitrogen increases with increase in brake power which is proportional to load for both Diesel and Animal tallow Biodiesel at 10% EGR and 20% EGR.The NO_xemission for Animal tallow biodiesel is lower compared with the diesel. The NO_xemission for Animal tallow biodiesel at 10% EGR is lower compared with the Diesel at 10% EGR. The NO_xemission for Animal tallow biodiesel at 20% EGR is lower compared with the Diesel at 20% EGR. The NO_xemissions decrease with increase in %EGR. The NO_xemission for Diesel at 20% EGR is lower compared with the Diesel at 10% EGR. The NO_xemission for Animal tallow biodiesel at 20% EGR is lower compared with the Animal tallow biodiesel at 10% EGR.

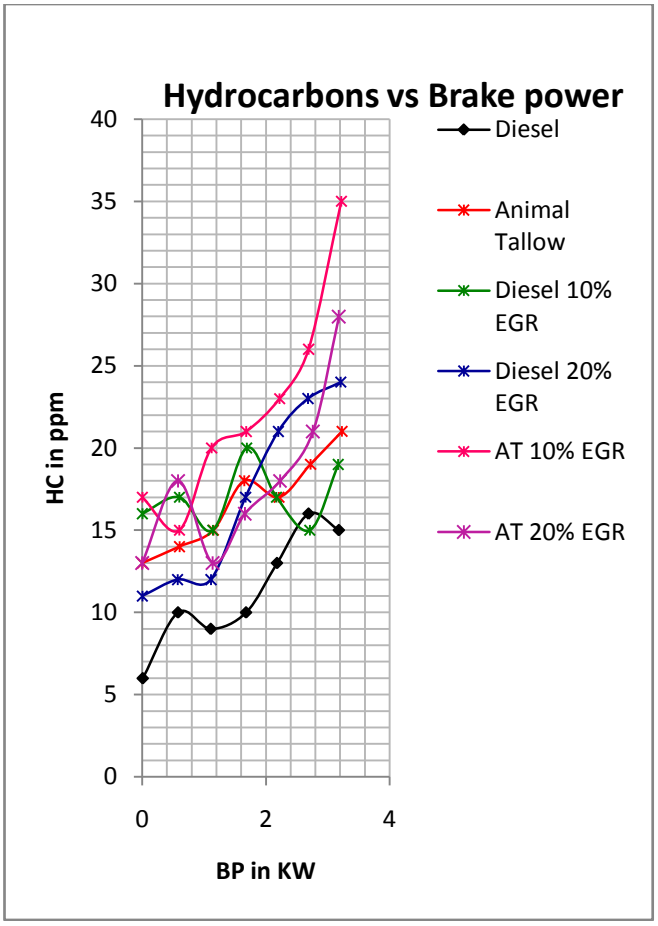

Figure 7: Variation Of Hydrocarbon Emission With Brake Power

Figure 7 shows the variation of Hydrocarbon emissions from the engine with respect to Brake power for Diesel and Animal Tallow Biodiesel at 10% EGR and 20% EGR. From the above variation it can be concluded that the Hydrocarbon emissions increases with increase in brake power which is proportional to load for both Diesel and Animal tallow Biodiesel at 10% EGR and 20% EGR. The Hydrocarbon emissions high at higher loads and low at lower loads for Diesel and Biodiesel for different rates of EGR used in this project. Hydrocarbon, carbon monoxide and carbon dioxide emissions are lower for diesel than animal tallow biodiesel. Hydrocarbon, carbon monoxide and carbon dioxide emissions increases with increase in rate of EGR because they depended on the combustion temperature. Mainly low combustion temperature regions such as boundary layer near the walls cause the formation of these emissions. From the experiment it was found that emission of HC, CO and CO_2 increased with increasing EGR rates, the possible reason may be decrease in combustion temperature or exhaust gas temperature.

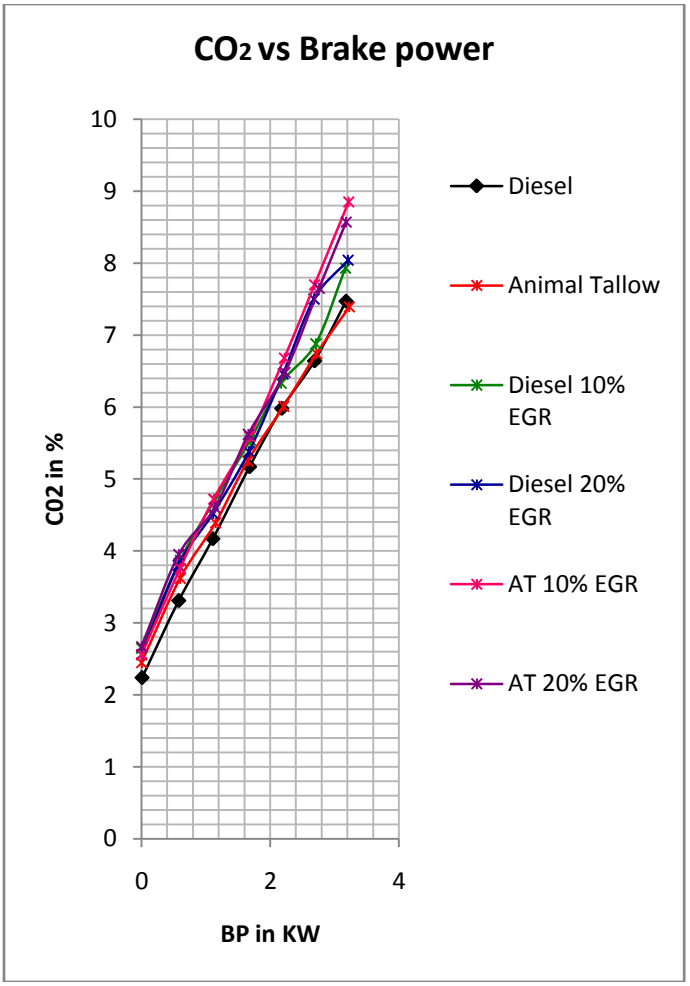

Figure 8: Variation Of Co_2 Emission With Brake Power

Figure 8 shows the variation of emission of CO_2 from the engine with respect to Brake power for Diesel and Animal Tallow Biodiesel at 10% EGR and 20% EGR.From the above variation it can be concluded that the % of CO_2 emission increases with increase in brake power which is proportional to load for both Diesel and Animal tallow Biodiesel at 10% EGR and 20% EGR respectively. The CO_2 emissions increase with increase in %EGR. The CO_2 emissions for Diesel with 10% EGR and 20% EGR are higher compared with the Diesel without EGR. The CO_2 emissions for Animal tallow biodiesel with 10% EGR and 20% EGR are higher compared with the Animal tallow without EGR.

CONCLUSION

It is observed from the experiment that engine operated with biodiesel using EGR technique have reduced emission values compared with engine operated with diesel using EGR. It has observed from figures that brake thermal efficiency for Bio-diesel blend is higher than base line data of diesel. It is also observed that there is reduction in the emission of Hydrocarbon HC, CO, NOx& smoke bio diesel operated with EGR.

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