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Effects of Exhaust Gas Recirculation on the Performance and Emission Characteristics of Diesel Engine using Biodiesel

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***Abstract-* Now a day's CI engines are significant prime movers because of its suitability, eases of drivability and thermal efficiency. In spite of their advantages they produce higher levels of NOX and smoke emissions which will more harmful to the environment. Hence there is a need to impose a stringent norms related to emissions. So in order to fulfill these emission norms and also to overcome the petroleum oil reserve problems which are going to be depleted in near future. The use of biodiesel in diesel engines will gives considerable lower emissions and at same time it was found that the biodiesel fuel engine produces higher NOX emissions compared to diesel engines. The aim of the present investigations is to reduce the NOX emissions using Exhaust Gas Recirculation (EGR). In this work the experiments will be conducted on a four stroke CI Diesel engine.**

Key words - Diesel Engine; EGR; Neem oil Methyl Ester,;Nox; Pollution.

I. INTRODUCTION

The world is presently confronted with double crises of fossil fuel depletion and environmental degradation. The fact that petroleum based fuels will neither be available in sufficient quantities nor at a reasonable price in future has revived interest in exploring alternative fuels for diesel engines [1]. Thermodynamic tests based on engine performance evaluations have established the feasibility of using a variety of alternatives such as CNG, LPG, alcohols, biogas and vegetable oils etc. vegetable-oil-based fuels have considerable potential as an appropriate alternative. Since the fuel properties are similar to that of petroleum diesel [2,3].

The major problem associated with direct use of raw vegetable oils is their viscosity. One possible method to overcome the problem of high viscosity is transesterification of oils to produce esters (commonly known as Biodiesel) of respective oils. Biodiesel is a non-polluting fuel made from organic oils of vegetable origin. Chemically it is known as free Fatty Acid Methyl Ester (FAME). The esters of fatty acids derived from transesterification of vegetable oils have properties closer to petroleum diesel fuels. These fuels tend to burn cleaner; perform comparably to conventional diesel fuel, and combustion is similar to diesel fuels[4,5].

Diesel fuels have deep impact on the industrial economy of a country. These are used in heavy trucks, city transport buses, locomotives electrical generators, farm equipments, underground mine equipments etc[6]. The consumption of diesel fuels in India for the period 2007-08 was 28.30 million tons, which was 43.2 percent of the consumption of petroleum products. This requirement was met by importing crude petroleum as well as petroleum products. The import bill on these items was 17,838 crores. With the expected growth rate for diesel consumption more than 14% per annum, shrinking crude oil reserves and limited refining capacity. India is likely to depend more on imported of crude petroleum products [7,8]

present paper deals with the result of exhaust gas recirculation with neem oil methyl ester (NOME) blends and diesel fuel and also is to investigate the emissions and performance parameters of a diesel engine with biodiesel as fuel. For this experimental study, 8 % EGR has been taken for analysis.

EXHAUST GAS RECIRCULATION

Figure 1 shows the exhaust gas recirculation (EGR) set up in the test engine used for controlling the Nox emissions. EGR is an effective technique of reducing NOx emissions from the diesel engine exhaust. EGR involves replacement of oxygen and nitrogen of fresh air entering in the combustion chamber with the carbon dioxide and water vapour from the engine exhaust. The recirculation of part of exhaust gases into the engine intake air increases the specific heat capacity of the mixture and reduces the oxygen concentration of the intake mixture. These two factors combined lead to significant reduction in NOx emissions. EGR (%) is defined as the mass percentage of the recirculated exhaust (MEGR) in total intake mixture (Mi).

$$\%EGR = \frac{\text{Mass of air admitted without EGR} - \text{Mass of air admitted with EGR}}{\text{Mass of air admitted without EGR}}$$

II. EXPERIMENTAL SETUP

TABLE-1 COMPOSITION OF FREE FATTY ACIDS

Sl.No	Fatty Acid Composition	Structure	Neem Oil
1	Palmitic Acid	C 16:0	16%
2	Stearic Acid	C 18:0	13%
3	Oleic Acid	C 18:1	46%
4	Linoleic Acid	C 18:2	14%
5	Linolenic Acid	C 18:3	--

The test engine which is used in this present investigation was a single cylinder four stroke water cooled, NA, DI diesel engine coupled with mechanical loading. An orifice box is connected to the inlet manifold and the air mass flow rate is measured using the U-tube manometer connected to the orifice box. The EGR system consists of a piping system taken from the engine exhaust pipe and filter is used to prevent smoke from re-entering the cylinder. Thermocouples are connected to inlet and exit of Manifolds. The probe of exhaust gas analyzer is inserted into the exhaust pipe for emission measurement. The engine is loaded using an rope brake dynamometer and the load on the engine is noted down. Instrumentation is provided for the measurement of fuel consumption and load on brake drum. The arrangement of experimental set up is shown in figure 1. The specifications of the test engine are as given in Table 1. The experiment was conducted with conventional diesel fuel, and neem oil methyl ester (NOME)

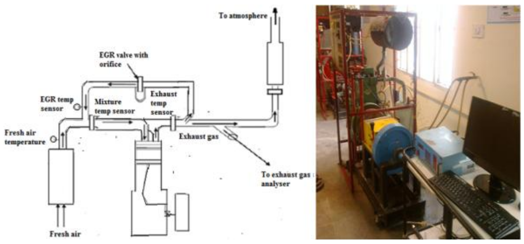

Fig.1 Experimental Setup Using EGR

Engine specifications:

BHP	5HP
Speed	1500 rpm
Bore	80mm
Stroke	110m
Compression ratio	16.5:1
Orifice diameter	17mm
Method of start	crank start
Make	Kirloskar

RESULTS AND DISCUSSIONS

Experiments on compression ignition engine were carried out using diesel at 1500 rpm and 8% EGR rate in order to study the smoke density and NOX concentration in the exhaust emissions. Advanced amount of smoke is observed at exhaust when the engine is operated with EGR compared to without EGR. Smoke emissions increase with increasing engine load and EGR rate. EGR decreases availability of oxygen for combustion of fuel, which results in relatively incomplete combustion and increased formation of NOME and reducing NOX emissions from diesel engine. Using biodiesel in diesel engine, smoke is decreased with increase in NOX. Thus, biodiesel with EGR can be used to reduce NOX and smoke intensity simultaneously. A number of experiments were carried out at 8% EGR using diesel, B20 and B10 NOME of biodiesel. The performance and emission data were analyzed when compared to without EGR for thermal efficiency, HC, CO and NOX.

PERFORMANCE ANALYSIS

- *Comparing brake specific fuel consumption (BSFC) and indicated specific fuel consumption of diesel with NOME.*

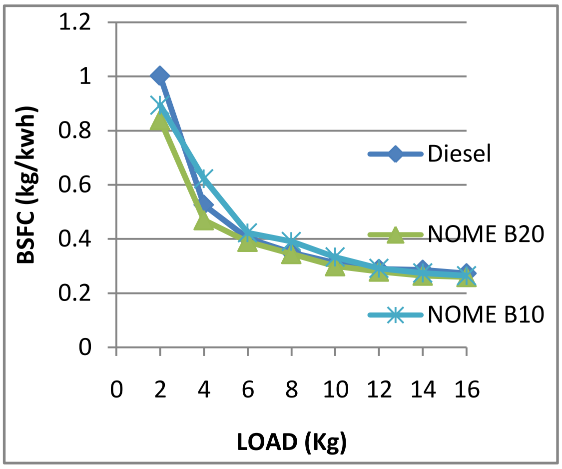

Fig.2 Comparison graphs of BSFC Vs load of NOME blends with Diesel

Fig.2 shows the comparison graph of Bsfc vs load of NOME blends with Diesel.

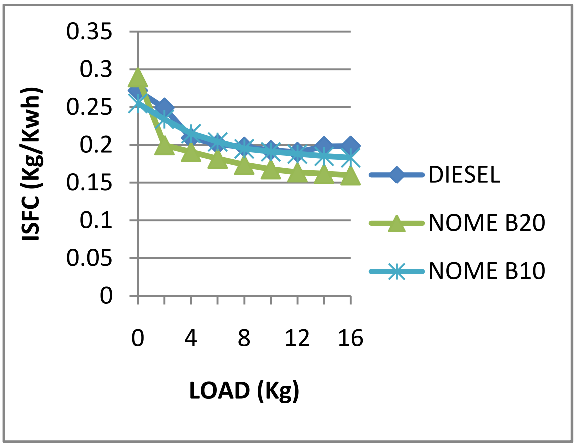

Fig.3 Comparison graphs of ISFC Vs load of NOME with Diesel

Fig.3 shows the comparison graph of Isfc vs load of NOME with diesel. After analyzing the brake and indicated specific fuel consumption (bsfc and isfc) in case of diesel, with Nome it has been found that the bsfc and isfc is decreasing for Bio-Diesel when compared to diesel.

Comparing Brake power and Indicated Power

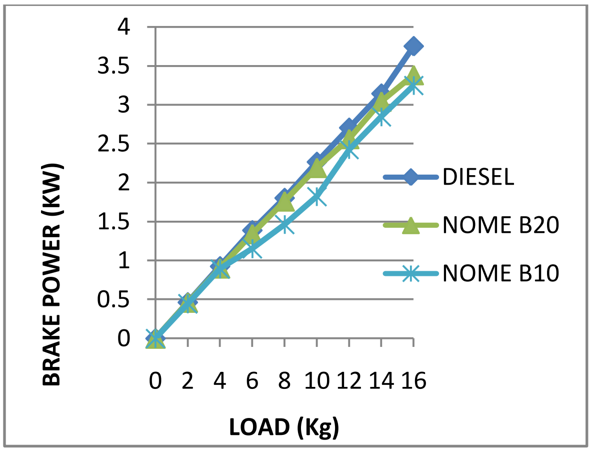

Fig.4 Comparison graphs of BP Vs Load of NOME with Diesel

Fig.4 shows the comparison graph of Brake power and load of NOME with Diesel. After analyzing the brake power in case of diesel, NOME it is found the brake power is slightly equal and increasing when compared to Diesel.

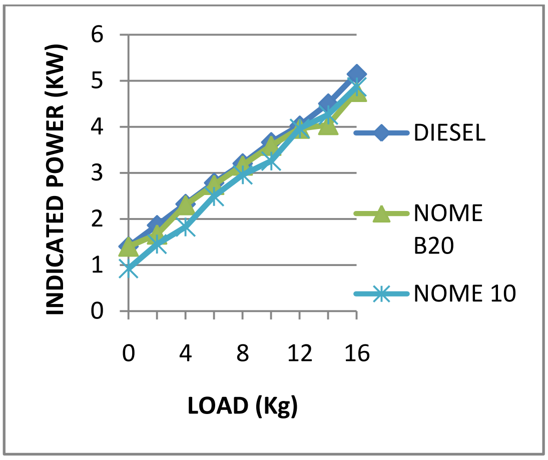

Fig.5 Comparison graphs of IP Vs Load of NOME with Diesel

Fig.5 shows that the comparison graphs of indicated power and load of NOME with Diesel. After analyzing the indicated power in case of diesel, NOME it has been found that the indicated power is decreasing when compared to diesel.

- Volumetric Efficiency

Comparing the Volumetric Efficiency of Diesel with NOME.

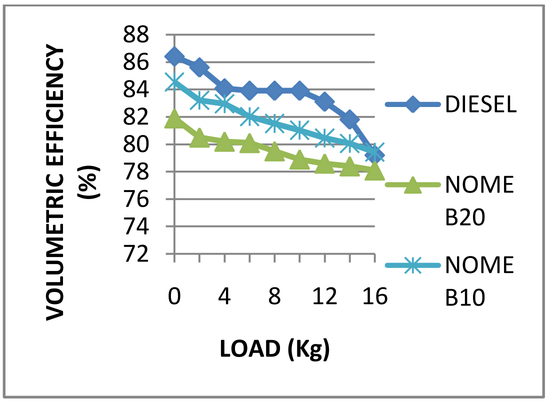

Fig.6 Comparison graphs of vol vs load of NOMEwith Diesel

Fig.6 shows that the comparison graphs of volumetric efficiency and load of NOME with Diesel. After analyzing the Volumetric Efficiency in case of Diesel, NOME it has been found that Volumetric Efficiency is increasing when compared to Diesel.

- Brake & Indicated Thermal Efficiency

Indicated thermal efficiency is ratio of energy in the indicated power (IP) to input fuel energy in appropriate units.Brake thermal efficiency is the ratio of energy in brake power (BP) to input fuel energy in appropriate units.

Comparing the Brake thermal efficiency & Indicated thermal efficiency of Diesel with NOME

Fig.7 shows the comparison graph of brake thermal efficiency and load of NOME with diesel

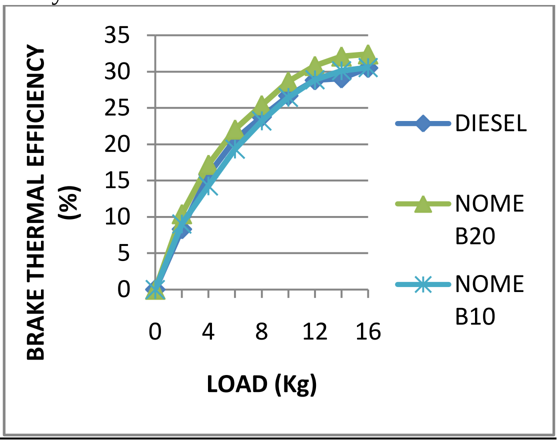

Fig.7 Comparison graphs of Brake Efficiency vs. Load of NOME with Diesel

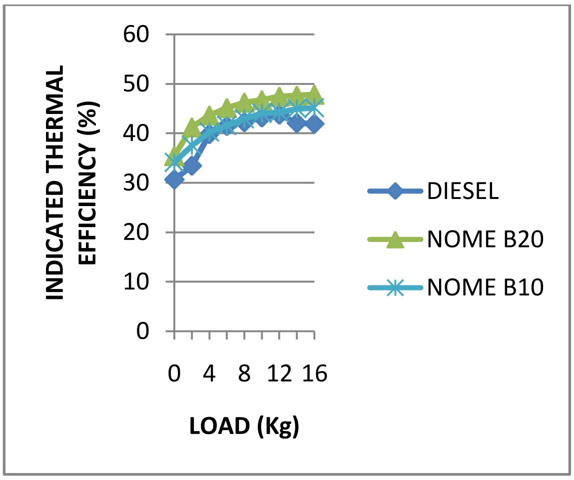

Fig.8 Comparison graphs of indicated Efficiency vs. Load of NOME with Diesel

Fig.8 shows that the comparison graphs of indicated thermal efficiency and load of NOME with Diesel. After analyzing the Brake thermal & indicated thermal efficiency in case of Diesel, NOME it has been found that the Brake thermal efficiency is increasing, and Indicated thermal efficiency is also increasing when compared with Diesel

- Mechanical Efficiency

Comparing the Mechanical efficiency of Diesel with NOME

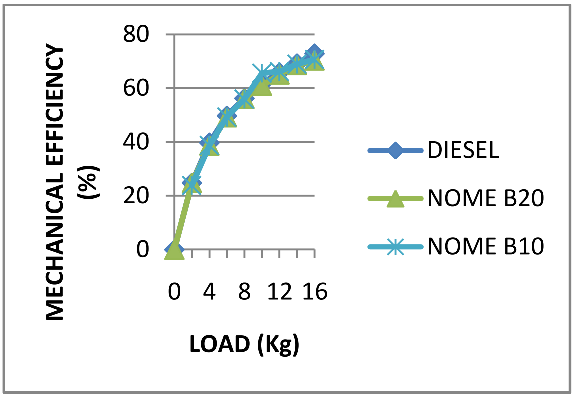

Fig.9 Comparison graphs of Mech Eff vs Load of NOME with Diesel

Fig.10 shows that the variation of hydrocarbon emission with load of NOME with Diesel After analyzing the Mechanical efficiency in case of Diesel, NOME it has been found that the mechanical efficiency is equal when compared to Diesel

A slight drop of efficiency was found with methyl esters (bio-diesel) when compared with diesel. This drop in thermal efficiency must be attributed to the poor combustion characteristics of methyl esters due to high viscosity. It was observed that the brake thermal efficiency of B10 and B20 are very close to brake thermal efficiency of diesel. B20 methyl ester had equal efficiency with diesel. So B20 can be suggested as best blend for bio-diesel preparation

Emission Characteristics Analysis

- *Unburnt Hydro Carbon Emissions (UBHC)*

Fig.10 shows the variations of UBHC emissions of diesel and palm methyl ester blends with and without EGR. The UBHC increases with increase in load and EGR rate. because of lower oxygen content available for combustion, that is lower excess oxygen concentration results rich mixture which results incomplete combustion and results higher hydro carbon emission. It is also observed from the graph the 10% and 20%biodiesel blend with 8% EGR gives 30% and 45 % lower UBHC emissions compared to diesel with EGR.

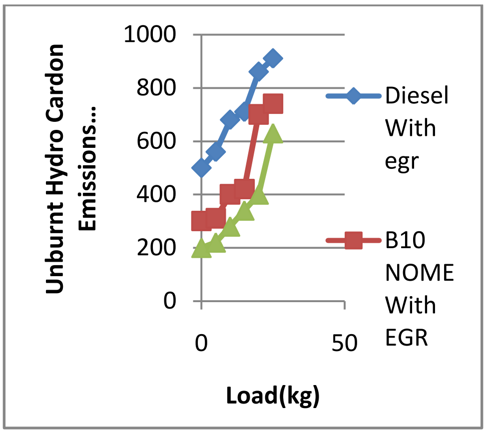

Fig.10 Variations of Hydrocarbon Emission with Load

○ *Carbon Monoxide Emissions (CO)*

Fig.11 shows the variations of CO emissions of diesel and palm methyl ester with EGR and without EGR. The CO increases with increase in load and EGR rate. However, CO emissions of PME were comparatively lower. Higher values of CO were observed at loads for both diesel and biodiesel fuels with EGR. For biodiesel, the excess oxygen content is believed to have partially compensated for the oxygen deficient operation under EGR. Dissociation CO2 to CO at peak loads where high combustion temperatures and comparatively fuel rich operation exists, can also contribute to higher CO emissions. It is observed that from the graph CO emissions are 8% and 25% lower for B10and B20 biodiesel blends respectively compared with diesel when the engine is operated with EGR

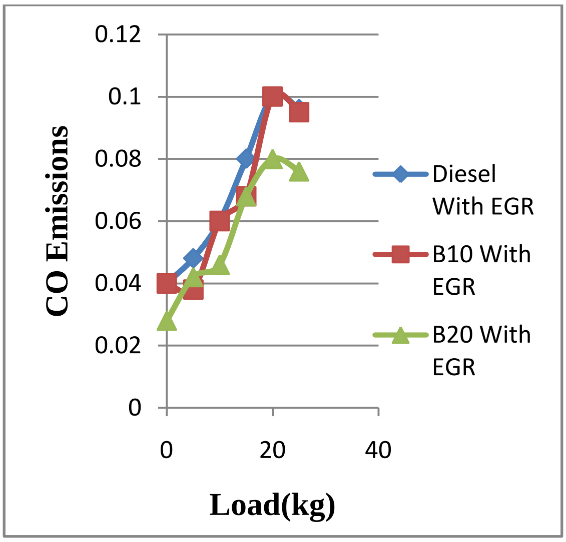

Fig.11 Variations of CO Emissions with Load

○ *Nitrogen Oxides Emission (NOX)*

Fig.12 shows the variations of NOx emissions of diesel and Palm oil methyl ester with and without EGR. The degree of reduction in NOx at higher at higher loads. The reasons for reduction in NOx emissions using EGR in diesel engines are reduced oxygen concentration and decreased the flame temperatures in the combustion chamber. However, NOx emissions in case of biodiesel blends without EGR are higher than diesel due to higher temperatures prevalent in the combustion chamber. It is also observed from the graph the 10 % and 20 % biodiesel blends have 15 % and 10 % lower NOx emissions respectively when compared to diesel fuel without EGR

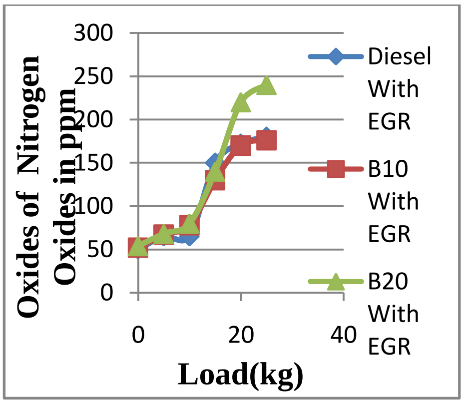

Fig.12 Formation of No_x Emissions with Load

CONCLUSION

Transesterification process is a method to reduce viscosity of vegetable oil with low production cost. The brake specific fuel consumption is increased about 6% for B10 and 10 % for B20 NOME blends with EGR due to lower calorific value of bio diesel and high viscosity of the NOME compared with diesel. The volumetric efficiency was reduced due to high specific heat of the gases when engine is operated with EGR.The brake thermal efficiency for B10 is similar to the diesel, but for B20 it was increased about 20% compared with diesel. The brake thermal efficiencies are improved with increasing concentration of bio diesel and its diesel blends due to the higher oxygen present in the bio diesel. The total un burnt HC and CO emissions were decreased by 30% and 8% for 10% biodiesel blends respectively compared to diesel fuel with EGR and smoke emissions were observed as increases, due to incomplete combustion. Compared with conventional diesel fuel, the exhaust NOx was reduced about 15% at 10 % biodiesel blends with 8% EGR due to less oxygen available in the recirculated exhaust gases which lowers the flame temperature in the combustion chamber. After analyzing the mechanical efficiency in case of diesel, NOME it has been found that the mechanical efficiency is equal when compared to diesel. Blending of 20% NOME resulted in an improvement in brake power, brake thermal efficiency, indicated thermal efficiency, volumetric efficiency and mechanical efficiency using NOME as fuel additive to diesel causes an improvement in engine performance and reduction in exhaust emissions. A diesel engine can perform satisfactorily on bio-diesel blends(B20) without any engine hardware modification.

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