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Effect Of Exhaust Gas Recirculation On The Performance And Emission Characteristics Of Diesel Engine With Orange Oil-Diesel Blend

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Abstract
As day by day there is technological development seen all around world, the research work is progressing but the resources involved in them are depleting rapidly .The demand of resources and fuels for the technological development is increasing day by day. In order to keep the pace of development high there is a need to think about some alternate fuel with better efficiency which would help overcome the demand keeping in mind the resources for the future generation. An alternate fuel needs to be developed and researched upon which could help us get greener and better tomorrow.One of the reasons for this is emission of exhaust gases like NO_X, CO, HC, etc., from I.C Engines. The amount of NOx formed is lesser when the blends of biodiesel are used. But Exhaust Gas Recirculation (EGR) for biodiesel blends the formation of NOx is comparatively reduced and also thermodynamic efficiency of the engine is increased.This work highlights upon the usage of Orange oil as alternative fuel for a compression ignition engine and study the performance and emission characteristics of this fuel with Exhaust Gas Recirculation system at different quantities of EGR rates with different loads.
Keywords*:* D.I.Diesel Engine, Performance, Emissions.

I. INTRODUCTION

In the present situation there is an absolute scarcity of fuel. Hence popularizing the slogans such as “Save Oil”, introducing new fuel saving vehicles, etc. It is necessary to introduce alternate fuel to replace the existing fossil fuels as it has been predicted by experts that the existing resources of the fossil fuels will be exhausted in another 50 years. As the situation is deteriorating day-by-day especially in developing countries like India, and have to think of introducing alternate fuels. Apart from the scarcity, the cost also is increased at regular intervals. Depending on this, country’s economy is also affected. Continuous search for the alternate fuels has lead researchers to several areas. They are alcohols, H_2, LPG, CNG, Biogas, Vegetable oils, etc. Out of these, Vegetable oils are becoming popular worldwide because it is renewable and they can be produced easily as the technology for extraction is well known.Alternate fuels which are extracted from Vegetable oils will positively reduce the usage of fossil fuels. There are various types of vegetable oils that can be used as alternate fuels. The different vegetable oils are: Jatropha oil, Cotton seed oil, Rubber seed oil, Rape seed oil, Rice bran oil, Orange peel oil. Out of these different vegetable oils, Orange peel oil is most important. Because the Calorific value of the Orange oil is almost equal to the calorific value of the Diesel. As Oranges are available in abundance in India, one can easily extract oil from its peel which can be successfully used as an alternate fuel to meet the requirements of fuel at the most economical rate. The oil extracted from Orange peel can be blended with Diesel and used in Diesel Engine. Several researchers have taken efforts to adopt suitable methods of using vegetable oils which exhibited improved performance and reduced emissions.

II. PROPERTIES OF ORANGE OIL

The Orange oil is extracted from the peel of the Orange fruit. The properties are shown in Table 1.

Table 1 Properties of Orange oil

Properties	Diesel	Orange oil
Calorific Value(kj/kg)	42,700	34650
Density at 30^0C(kg/l)	0.85	0.8169
Flash point (^{0}C)	52	74
Fire point (^{0}C)	65	82
Cetane number	50	47
Kinematic viscosity at 40 ^{0}C (Cst)	2.7	3.52

III. SPECIFICATIONS OF DIESEL ENGINE

The engine which is supplied by New Kirloskar Company the engine is single cylinder vertical type four stroke, water-coo1ed, and compression ignition engine. The engine is self-governed type whose specifications are given in Table 2 is used in the present work.

Table 2 Engine specifications

Item	Specification
Engine	Kirloskar Engine, 4 stroke-stationary.
Type	water-cooled
Injection	direct injection (DI)
Maximum speed	1500
Number of Cylinder	One
Bore	85 mm
Stroke	110 mm
Compression Ratio	16.5:1
Maximum HP	5 HP
Injection timing	25^0 before TDC
Injection pressure	200 bar

IV. EXHAUST GAS RECIRCULATION ARRANGEMENT

Diesel engine EGR systems comprise of a number of different components, each with a different function, which connect the exhaust to the intake system.

Fig 1Experimental set up

a) Pre-mixing chamber: The material selected to prepare the pre-mixing chamber is galvanized iron. The length and diameter of pre-mixing chamber are 20cm & 8.5cm. In this chamber, the air coming from the atmosphere and the exhaust gases are mixing together and sent into the engine intake manifold. This chamber consists of a small provision at bottom end to measure intake charge temperature.

b) Gas flow meter: This flow meter consists of glass body, tube, needle, and regulator.The main function of this gas flow meter is to measure the gas flow rate in terms of liters per minute. The range of gas flow meter is 0 to 10%. Accuracy of this gas flow meter is ±0.25%.

c) Exhaust gas regulator: The main function of this regulator is to control the flow of exhaust gases. It regulates the flow of exhaust gases from settling chamber to the pre mixing chamber.

d) Settling chamber: The material selected to prepare the pre-mixing chamber is galvanized iron. The length and diameter of pre-mixing chamber are 25cm & 8.5cm. In this chamber a part of the exhaust gases re-circulated and remaining are sent to the atmosphere. This chamber consists of a small provision at one end to measure the exhaust gas temperature.

e) Copper tube: Copper tube is connected between the gas flow meter, premixing, and settling chambers. Copper tube is a connection pipe between flow meter, pre mixing chamber and settling chambers. The main aim of selection of copper tube is it reduces the exhaust gas temperatures and easy to adjust in any direction. The diameter of copper tube is 8cm.

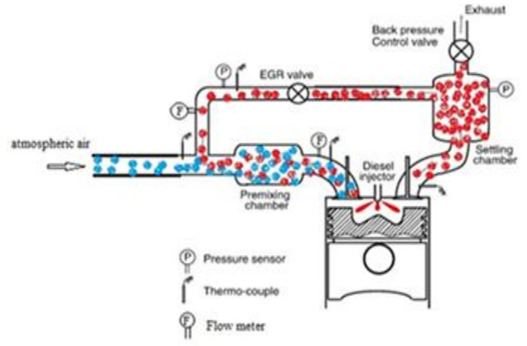

Fig 2Exhausts Gas Recirculation arrangement

V. Experimental Procedure

The experiments are conducted on single cylinder four stroke water cooled direct injection diesel engine Kirloskar engine. The engine was coupled to an eddy current dynamometer to measure the output. Fuel flow rates were timed with calibrated burette. Exhaust gas analysis was performed using exhaust gas analyzer.

VI. RESULTS AND DISCUSSION

Based on the experimental data the graphs are drawn. These graphs show the variation in brake thermal efficiency, Brake specific fuel consumption (BSFC), Hydrocarbon (HC), Carbon monoxide (CO), Nitrogen oxides (NO_x) emissions at various EGR rates.

6.1 SPECIFIC FUEL CONSUMPTION

For diesel and bio diesel, the variation of specific fuel consumption with Load was shown in Fig 3 and 4. Specific fuel consumption without EGR, under full load was found to be 0.2654 kg/kW-hr for diesel and 0.281 kg/kW-hr for biodiesel. Full load values of diesel with 0%, 10%, 20%, and 30% EGR were 0.2654, 0.2746, 0.2753 and 0.2787 kg/kW-hr respectively whereas it was 0.281, 0.26, 0.266, and 0.273 kg/kW-hr for bio diesel. For higher level of EGR 20%, specific fuel consumption increased for both diesel and biodiesel. Slightly higher values of biodiesel were due to lower calorific values and higher viscosity, density and boiling point.

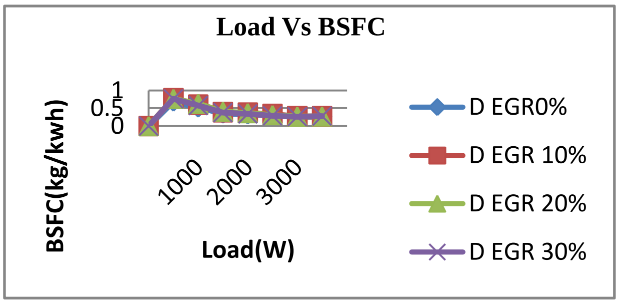

Fig 3 Specific fuel consumption (Diesel) Vs LoadFig

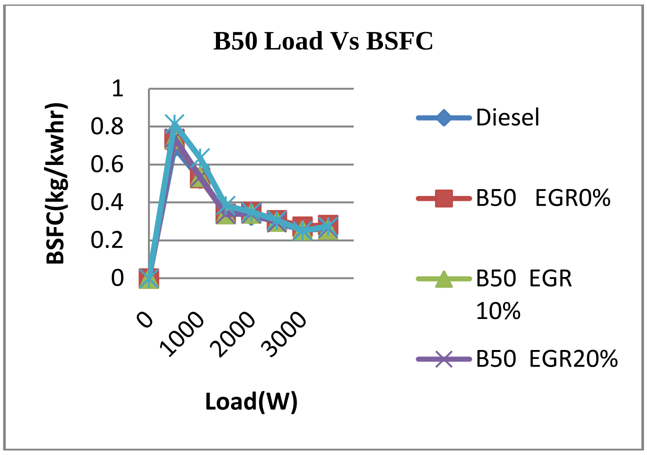

Fig 4 Specific fuel consumption (B50) Vs Load

6.2 BRAKE THERMAL EFFICIENCY

For diesel and bio diesel, the variation of brake thermal efficiency with Load was shown inFig 5 and 6. It indicates the variation in brake thermal efficiency with Load. Brake thermal efficiency with and without EGR was found to be comparable for diesel and bio diesel. At 3000W load brake thermal efficiency of 31.38% was obtained for diesel without EGR whereas it was 34.45% using biodiesel without EGR. Brake thermal efficiency of biodiesel at 20% EGR was maximum for different loads when compared with diesel, Brake thermal efficiency of Biodiesel at of 20% EGR was maximum for different loads when compared with without EGR .This is probably due to increased combustion velocity because of higher intake charge temperature with EGR. With dissociation of carbon monoxide, free radicals were formed. This can also be a cause for improvement in efficiency. In full load 20% EGR, brake thermal efficiency was reduced in diesel and biodiesel. More exhaust gases produced due to predominant dilution effect of EGR in combustion chamber results in efficiency drop.

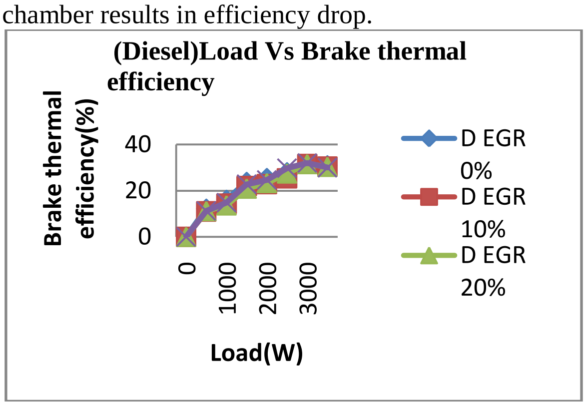

Fig 5 Brake thermal efficiency (Diesel) Vs Loa

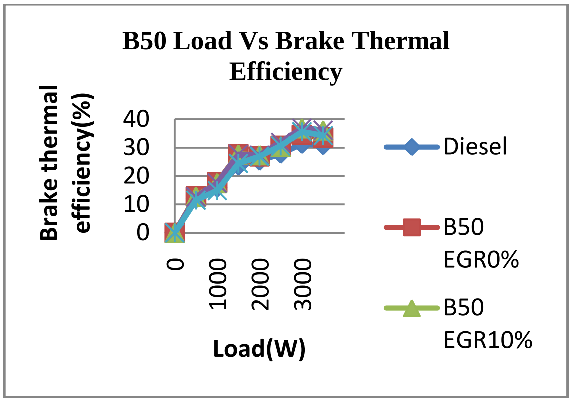

Fig 6 Brake thermal efficiency (B50) Vs Load

6.3 HYDROCARBON EMISSION

For diesel and bio diesel, the variation of hydrocarbon with Load was shown in Fig7 and 8.With increase in EGR levels, HC emission also decreases for biodiesel. In Full load condition HC emission was measured as 58 ppm in diesel and 56 ppm in biodiesel without EGR. At the same full load condition with higher EGR level HC emission varies from 57 to 59 ppm in diesel and 58to 51 ppm in bio diesel. This is due to richer mixture at full load and oxygen deficiency might have dominated as EGR was applied.

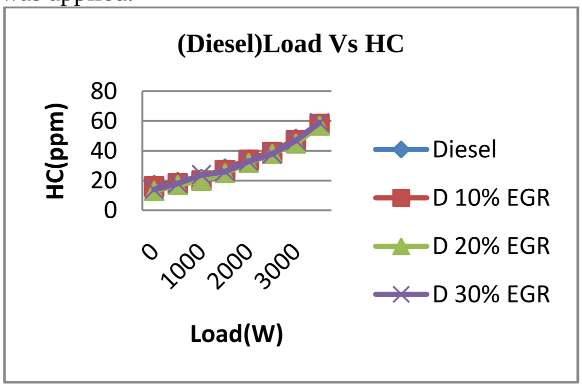

Fig 7 Hydro carbon (Diesel) Vs Load

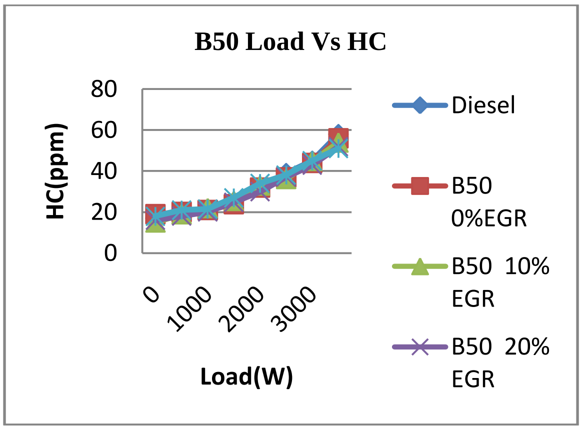

Fig 8 Hydro carbon (B50) Vs Load

6.4 CARBON MONOXIDE

For diesel and bio diesel, the variation of carbon -monoxide with Load was shown in Fig9 and 10.Fig. 9 and 10 depicts the variation in CO levels for diesel and biodiesel operation with various EGR levels for different load conditions. CO level for diesel varies from 0.31 (% by volume) for diesel and 0.318(% by volume) for biodiesel at full load without EGR. In lean mixture condition engine emits less amount of carbon monoxide. In the case of 20% level EGR CO emission was 0.3 (% by volume) for diesel and 0.307 (% by volume) for biodiesel at full load.

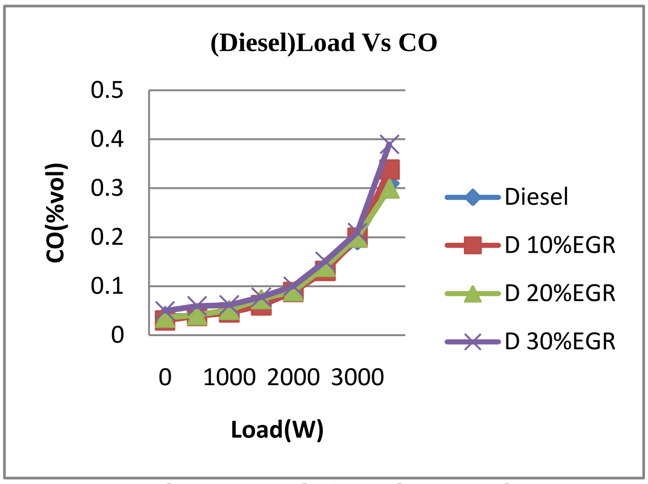

Fig 9 Carbon monoxide (Diesel) Vs Load

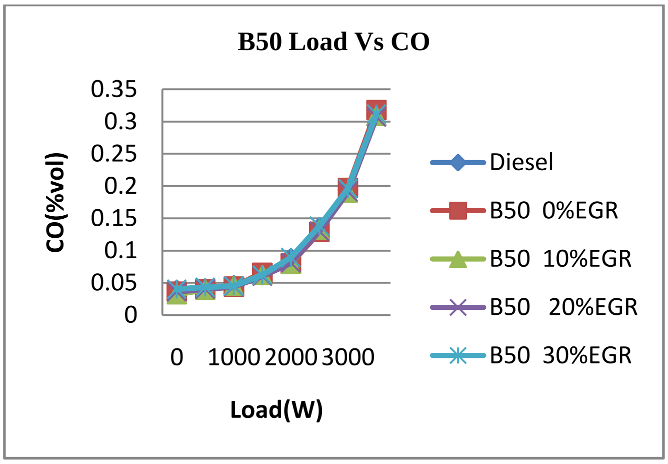

Fig 10 Carbon monoxide (B50) Vs Load

6.5 OXIDES OF NITROGEN

For diesel and bio diesel, the variation oxides of nitrogen with Load was shown Figures 11 and 12.Figures 11 and 12 indicate the variation of nitrogen oxide with brake power. NOx value was found to be 740 ppm for diesel and 735 ppm for biodiesel without EGR at full load condition. This was due to peak combustion temperature inside the cylinder. With increases in EGR level, the NOx value gets reduced. With 30% EGR, NOx levels were 670 ppm for diesel and 621 ppm for biodiesel. With increase in EGR level NOx level was reduced. Also reduction in brake thermal efficiency and large increase in smoke density were observed.

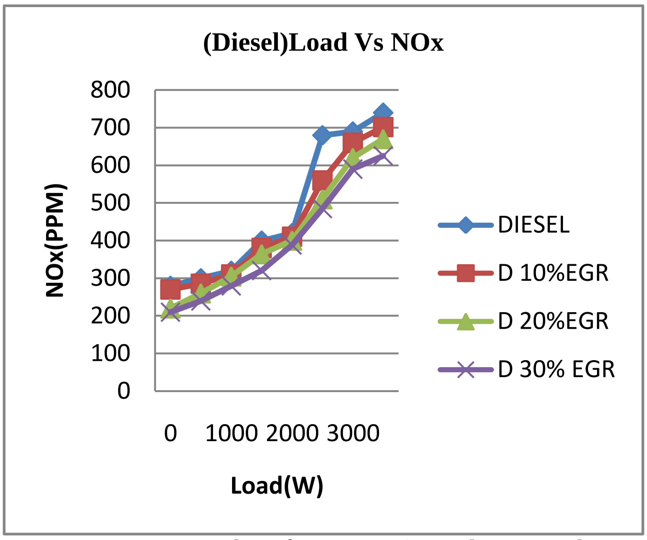

Fig 11 Oxides of Nitrogen (Diesel) Vs Load

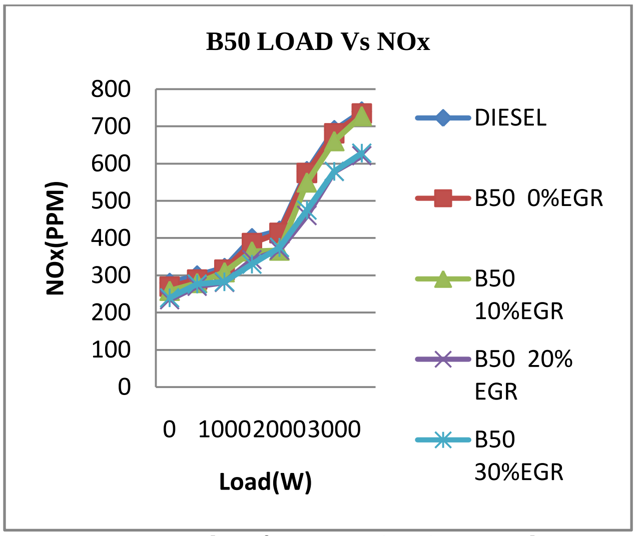

Fig 12 Oxides of Nitrogen (B50) Vs Load

VII. CONCLUSION

The conclusions based on the experimental results obtained while operating single cylinder water cooled diesel engine operated with EGR system using Orange oil blend (B50).

[0] Brake thermal efficiency is increased by 5.46% at 20% EGR, when compared to Pure Diesel at load 3000W respectively.
[1] Brake specific fuel consumption for all EGR openings at full load remains unchanged when compared to Diesel.
[2] The Mechanical efficiency is increased at 20% EGR by 0.49%, when compared to Diesel at load 3500W.
[3] Volumetric efficiency is increased by 4.8% at 20% EGR, when compared to Pure Diesel at full load.
[4] Exhaust gas temperature for all EGR openings are quietly increased when compared to Pure Diesel.
[5] Hydro carbon emission at 20% EGR is decreased when compared to Pure Diesel at load 2500W.
[6] Carbon monoxide emissions at 20% EGR are decreased by 0.008%, when compared to Pure Diesel at full load.
[7] Carbon dioxide emissions at 20% EGR are decreased by 0.4%, when compared to Pure Diesel at load 2500W and 3000W.
[8] NO_x emissions are greatly decreased for all EGR openings, when compared to Pure Diesel. From the above investigation, it is recommended that EGR system at loads 2500W & 3000W for 4-stroke single cylinder diesel engine is preferable at 20% EGR rate.

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