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Research Article

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Effect of exhaust gas recirculation on NOx emission of a annona methyl ester operated diesel engine

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ABSTRACT

To meet stringent vehicular exhaust emission norms worldwide, several exhaust pre-treatment and post treatment techniques have been employed in modern engines. Exhaust Gas Recirculation (EGR) is a pre-treatment technique, which is being used widely to reduce and control the oxides of nitrogen (NOx) emission from diesel engines. EGR controls the NOx because it lowers oxygen concentration and flame temperature in the combustion chamber. The experiments were carried out to experimentally evaluate the performance and emissions for different EGR rates of the engine using A20 (20% Annona Methyl Ester + 80% Diesel) as a fuel. Emissions Parameters such as hydrocarbons (HC), NOx, carbon monoxide (CO), and smoke were measured. Performance parameters such as brake thermal efficiency, brake specific fuel consumption (BSFC) were also calculated. It is concluded that for the A20 blend of Annona Methyl Ester (AME) shows reduction in NOx was observed without any engine modification.

Keywords: Performance, emission, EGR, Annona Methyl Ester, Diesel Engine.

INTRODUCTION:

Last few years world nations developments increase very rapidly by consumption of fuels so the emission of fuels widely damaged the world climate like the word “Global Warming” is became very popular in now days and this is because of emission of different fuels so controlling of emissions are very important and today different experiments are done for controlling of emissions. Today the consumption of Diesel becomes more especially in transportation and industries so for controlling of diesel emission. Exhaust Gas Recirculation process is really useful technique in controlling oxides of nitrogen in diesel engines but it’s not give proper result at higher loads and higher percentage of recirculated gas because combustion tends to deteriorate at higher loads leading to reduced engine thermal efficiency and increased hydrocarbon and smoke emission so mixing of ethanol in diesel increase cetane index and kinematic viscosity.10% EGR is very effective from the others because its increase thermal efficiency, decrease tremendous amount of NOx, decrease fuel consumption, decrease HC at lower load, decrease O2intake in combustion chamber [1].EGR is the most influencing factor at no load and part load to reduce NOx emission with less influence on smoke density while at full load fuel injection timing is more influential [2].An experimental investigation was conducted on a direct injection (DI) diesel engine with exhaust gas recirculation (EGR), coupled with port fuel injection (PFI) of n-butanol. Result shows that under low EGR rate condition, both the peak cylinder pressure and the peak heat release rate increase with increased butanol concentration, but no visible influence was found on the ignition delay. Under high EGR rate condition, however, the peak cylinder pressure and the peak heat release rate both decrease with increased butanol concentration, accompanied by longer ignition delay and longer combustion duration [3]. The impact of EGR was evaluated experimentally and compared with neat diesel fuel (i.e., Bu00). The results show that Bu40 has higher cylinder pressure, longer ignition delay, and faster burning rate than Bu00. Compared with Bu00, moreover, Bu40 has higher NOx due to wider combustion high-temperature region, lower soot due to lower equivalence ratio distribution, and higher CO due to lower gas temperature in the late expansion process. For Bu40, EGR reduces NOx emissions dramatically with no obvious influence on soot. Meanwhile, there is no significant change in HC and CO emissions and indicated thermal efficiency (ITE) with

EGR until EGR threshold is reached. When EGR rate exceeds the threshold level, HC and CO emissions increase dramatically, and ITE decreases markedly [4].The recirculation of exhaust gas reduces the oxygen quantity in the combustion chamber and increases the temperature of intake charge which reduces the flame temperature and makes to lower NOx formation. By increasing the cooled EGR rates reduces the emissions more effectively. Experimental results shows that the cold EGR is much effective than the hot and intermediate EGR for the reduction of NOx emission. The increase in temperature of EGR gases causes to increase the combustion temperature which leads to increase in formation of NOx [5].With the introduction of EGR, particulate number concentration and CO emissions decrease. Moreover, npropanol/gasoline blends produce higher CO and particulate matter number concentration compared to iso-propanol/gasoline blends at the same blending ratio due to their distinctive molecular structures and properties [6]. Exhaust gas recirculation (EGR) proved to be an effective way to reduce the NOx emissions. Test results show that the brake thermal efficiency increases with the increase in the percentage of EGR which is accompanied by a reduction in brake specific fuel consumption and exhaust gas temperatures, and that biodiesel with cetane improver under 20% EGR reduces NOx emissions by 33% when compared to baseline fuel without EGR. However carbon monoxide (CO), hydro carbon (HC) and smoke emissions increase with an increase in percentage of EGR [7].

EXPERIMENTAL SECTION

1.1. *Engine description*

Facilities to monitor and control engine variables such as engine speed, load, fuel and air flows, etc., are installed on a computerised Vertical 4 stroke, Single Cylinder, water cooled DI CI Engine. The engine basic data are given in Table-1and Fig. 1 gives a full schematic arrangement of the engine test bed.

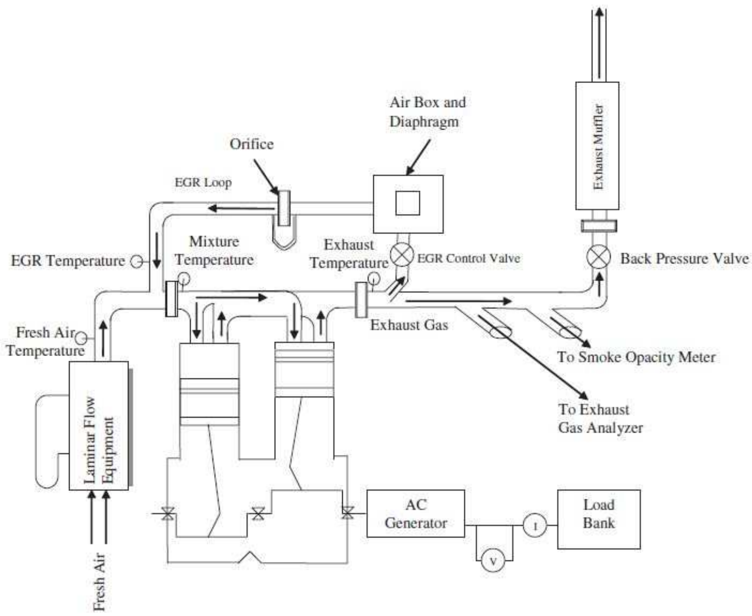

Fig-1: Schematic Diagram of experimental setup

Table-1: Engine Specification

Manufacturer	Kirloskar oil engines limited
Type of Engine	Vertical, 4-Stroke Single cylinder
Model	SV1
Rated OutputAs per IS: 11170	8 HP (5.9kW)
Speed	1800 rpm
Compression Ratio	17.5:1
Bore and stroke	87.5 x 110 (mm)

2.2. Exhaust gas analyzers system

The exhaust gas analysis system consists of an AVL 437 smoke meter to measure the smoke level in the exhaust gas and AVL di gas 444 to measure the concentrations of various elements in the exhaust gas. The Specification of the exhaust gas analyzer is shown in Table-2.

Table-2: Exhaust Gas Analyzer Specifications.

Manufacturer	SMS Autoline Equipments private limited
Type	Crypton 290 five gas analyser
Accuracy	HC:±30ppm,CO:±0.2%,CO_2:±1%,NO_x:±10ppm

2.3. Smoke meter:

Smoke meter is used to determine the smoke density of the engine exhaust. The AVL 437 smoke meter has been designed for simple one man operation either from alongside a vehicle for either free acceleration or steady state test procedures. Control is via a compact and rugged handset with a digital L.C.D. display. Any out of range parameters are automatically flagged to the operator. The brief specification of the smoke meter is shown in Table 3.

Table-3: Smoke Meter Specifications.

Type	AVL 437 smoke meter
Make	AVL India Pvt. Ltd
Measuring range	0 to 100 HSU
Accuracy	±10HSU

2.3. Properties of fuels

Annona Methyl Ester derived from the raw Annona oil obtained from Annona seeds are transesterified to remove the fatty acids. It was blended with the normal diesel fuel at blending ratio of 20%AME and 80% Diesel. The properties of the diesel fuel and the AME are summarized in Table-4 for comparative purposes.

Table-4: Properties of Diesel &AME

Fuel Properties	Diesel	AME
Density @20^{0}C (kg/m^3)	837	880.2
Cetane number	50	52
Calorific Value (MJ/kg)	43	36.4
Kinematic viscosity @40^{0}C (mm^2/s)	2.6	5.18
Latent heat of evaporation (KJ/kg)	250	585
Oxygen (%wt)	0	19
Flash point (^{O}C)	56	76
Fire point (^{O}C)	64	92

3. EXPERIMENTAL PROCEDURE

The experimental work started with a preliminary investigation of the engine running on neat diesel fuel, in order to determine the engine operating characteristics and exhaust emission levels, constituting the 'baseline' that is compared with the corresponding cases when using the Annona–diesel fuel blends .Annona biodiesel blend (AME20) is considered as the best blend and hence the performance and emission characteristics for various EGR (5%, 10%, and 15%) ratios are analysed for the specific blend. The engine was left to run for about 15 min to stabilize at its new condition. The corresponding change in performance and emission characteristics are measured and tabulated. The exhaust gas sample from exhaust pipe line is passed through a four gas analyzer for measurement of carbon monoxide, unburnt hydrocarbon, oxides of nitrogen present in exhaust gases. A smoke meter is used for measurement of smoke capacity. The measurement range and accuracy of the exhaust gas analyzer and smoke meter is shown in Table 5.

Table-5: Experiment Uncertainties

Parameters	Systematic Errors (±)
Speed	1 ± rpm
Load	± 0.1 N
Time	± 0.1 s
Brake power	± 0.15 kW
Temperature	± 1°
Pressure	± 1 bar
NOX	± 10 PPM
CO	± 0.03%
CO2	± 0.03%
HC	± 12 PPM
Smoke	± 1 HSU

RESULTS AND DISCUSSION

4.1 Performance Characteristics
4.1.1 Brake Thermal Efficiency
The brake thermal efficiency is simply the inverse of the product of the specific fuel consumption and the lower calorific value of the fuel. Fig 2 shows the variation of brake thermal efficiency with brake power for A20 at different EGR rates. It is observed that for A20 blend, the brake thermal efficiency is almost same that of neat diesel fuel and A20 with 5% EGR; it tends to reduce with increase in EGR percentage. This is due to re-burning of hydrocarbons that enter the combustion chamber with the exhaust gas recirculated.

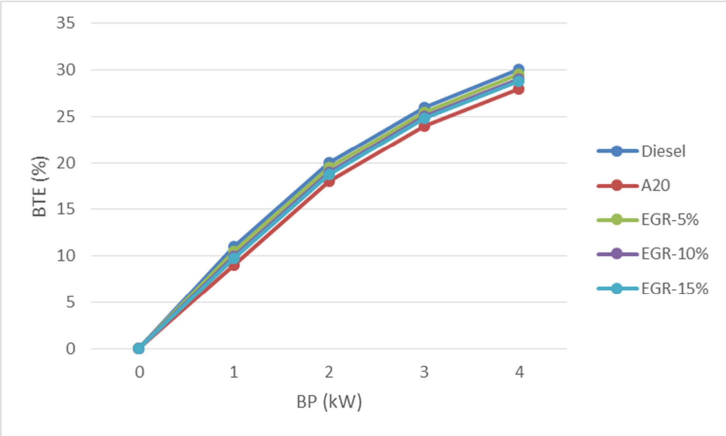

Fig-2: BP vs Brake Thermal Efficiency for different EGR rates

4.1.2 Brake Specific Fuel Consumption
Fig 3 shows the variation of brake specific fuel consumption with brake power for A20 at different EGR rates. It is observed that for A20 blend, brake specific fuel consumption is slightly higher than that of neat diesel fuel and A20 with 15% EGR rate. This is due to increasing of amount of fuel supplied and reduction of oxygen for combustion. Thus, air fuel ratio is changed and this increases the BSFC.

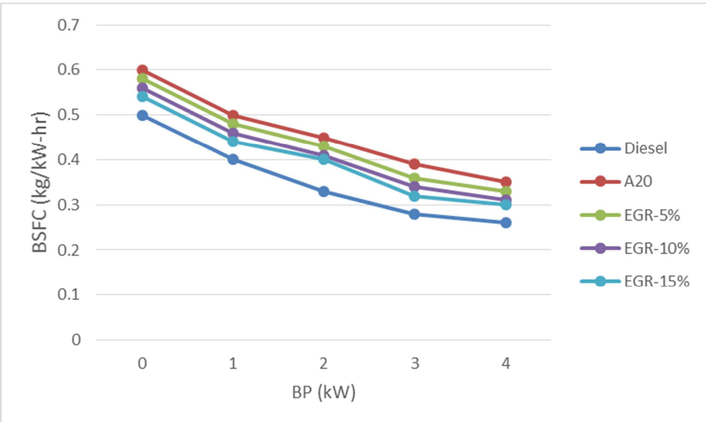

Fig-3: BP vs Brake Specific Fuel Consumption for different EGR rates

4.2 Emission Characteristics
4.2.1 Hydrocarbon and Carbon monoxide emission
Fig 4 and 5 shows the variation of hydrocarbon and carbon monoxide emission with brake power for A20 at different EGR rates. The HC and CO emission is increasing with increasing EGR rates. This is due to heterogeneous mixture does not combust completely and results in higher hydrocarbons.

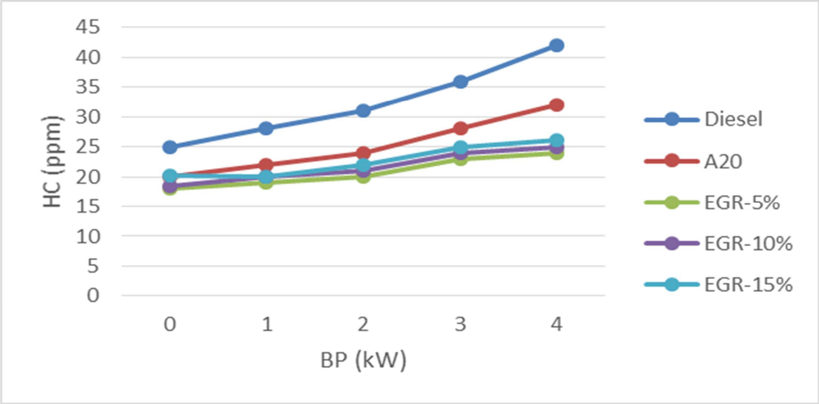

Fig-4: BP vs Hydro Carbon for different EGR rates

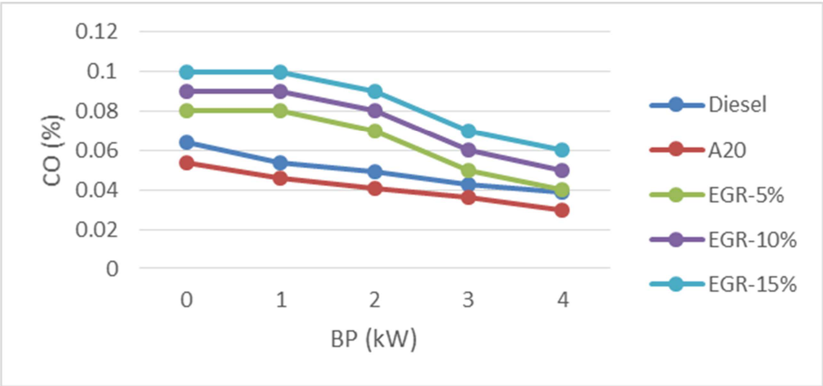

Fig-5: BP vs Carbon monoxide for different EGR Rates

4.2.2 Oxides of Nitrogen

Fig 6 shows the variation of oxides of nitrogen emission with brake power for A20 at different EGR rates. It is observed that for A20 blend, oxides of nitrogen emission is lower than that of neat diesel fuel and A20 with 15% EGR rate. This is due to reduced oxygen concentration and decreased flame temperature in the combustible mixture.

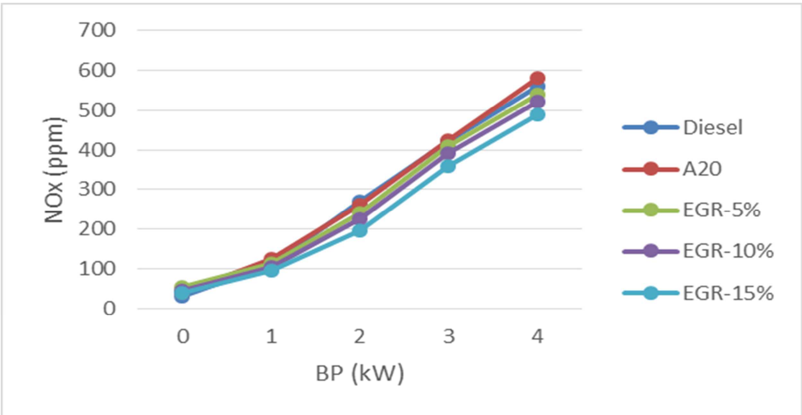

Fig-6: BP vs Oxides of Nitrogen for different EGR rates

4.2.3 Smoke

Fig 7 shows the variation of smoke with brake power for A20 at different EGR rates. It is observed that for A20 blend at 15% EGR is higher than that of neat diesel fuel .This is due to reduction in availability of oxygen which leads to incomplete combustion which in turn increase the smoke emission.

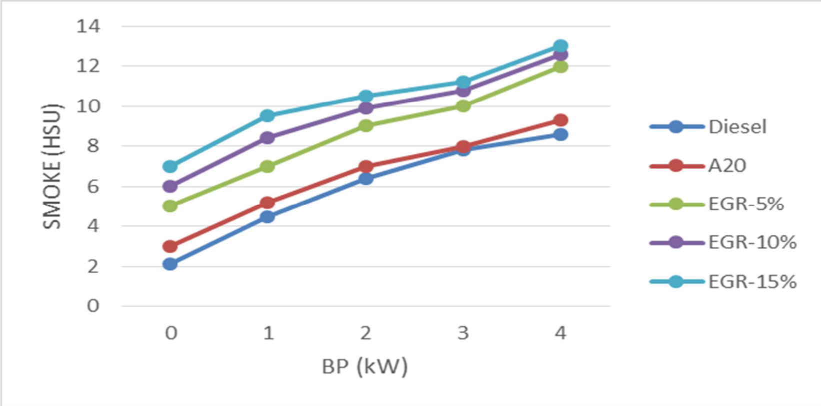

Fig-8: BP vs Smoke

CONCLUSION

Owing to the experimental results obtained using EGR the following conclusions are made.

i. EGR influence increases BTE and also reduces BSFC compared to that without EGR.
ii. HC,CO and smoke emission is increased with higher EGR rates and which can be reduced by Oxidation Additives and Soot traps.
iii. EGR reduces oxides of nitrogen emission but deteriorates the performance and engine emission.

Finally, it can be concluded that EGR can be applied to the engine without sacrificing engine efficiency and fuel economy and NO_x reduction can be achieved.

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