Effect of Exhaust Gas Recirculation on the Performance and Emission Characteristics of CI Engine Fuelled with Diesel – Compressed Biogas and ROME – Compressed **Biogas**

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ABSTRACT

In the present study, an experimental work had been carried out to analyze the performance, and emission characteristics of diesel engine by varying the EGR when fuelled with diesel – CBG and ROME – CBG at 80% and 100% load. From the test results it was observed that, maximum brake thermal efficiency, lower emissions of NOx and higher emissions of smoke, HC, CO were observed at 10% EGR as compared to 5% EGR.

Keywords: *EGR, performance, emission, ROME, compressed biogas*.

Abbreviations*: CBG – Compressed biogas*
ROME – Rice bran methyl ester
CNG – Compressed natural gas
LPG – Liquefied petroleum gas
EGR – Exhaust gas recirculation

1. Introduction

In the present scenario if we observe the effect of fossil fuels on environment, health of the human being, investment on the fuels for importing etc. it is clear that biofuels have advantages in terms of renewable, biodegradability, energy security, environmental concerns, foreign exchange savings and socio-economic issues compared to fossil fuels. Therefore renewable fuels can be used predominantly used as fuel for transportation and power generation. Research works have been conducted on biogas production, purification, bottling and usage of bottled or compressed biogas (Bio-methane) in vehicles and also utilized in the generation of electricity. Biogas production from waste is not only renewable, also leads to sustainable development of the country. Along with biogas, biodiesel production also carries lot of importance. Biodiesel from non-edible oils have the ability of 100% replacement of the fossil fuels in IC engines without any modification. Vegetable oils have considerable potential to be considered as appropriate alternate fuel as they possess fuel properties similar to that of diesel. India has rich and abundant forest resources with wide range of plants and oil seeds. There are more than 300 different species of trees available in India. The oils can be obtained from many oil seeds. Based on the application or use of vegetable oils, the vegetable oils are classified into two types, namely edible and non-edible oils. Economics of the biodiesel production process can be improved, if non-edible oils are used. Use of edible oils in diesel engines is not encouraged as it is in great demand for human consumption. Therefore only non-edible vegetable oils can be seriously considered as fuel for CI engine. As far as low emission fuels are concerned gaseous fuels appears to be capable of performing a prominent role. Various gaseous fuels such as Biogas, Producer Gas, Hydrogen, LPG and CNG are suitable for IC Engines. CBG is considered as a better alternative fuel for CI engines because of availability of raw material (waste) for the production and drastic reduction of exhaust emissions. One of the main motivations to operate engines on gaseous fuel is that exhaust smoke and engine deposits are drastically reduced and they can be adopted for the current engines with slight modification at relatively low cost.

2. Methodology

A. Transesterification

It is most commonly used and important method to reduce the viscosity of vegetable oils. In this process triglyceride reacts with three molecules of alcohol in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and glycerol. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called esterification.

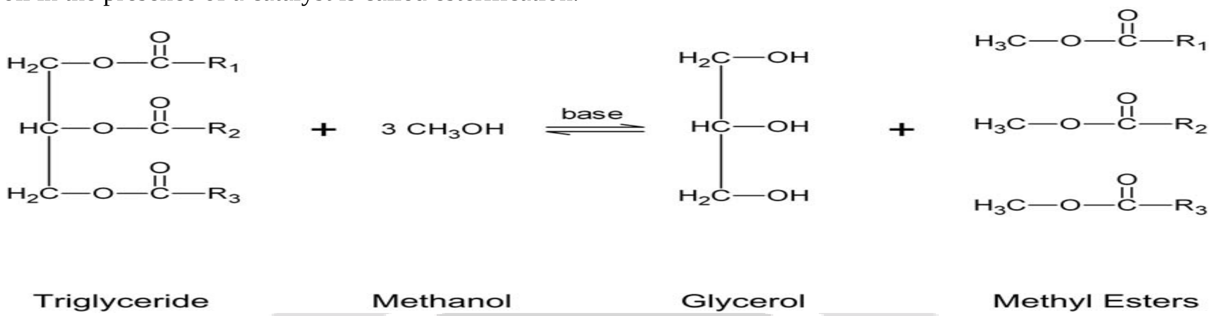


Fig 1: Chemical reaction.

B. Properties of fuels

Properties	Diesel	ROME	CBG
Viscosity @ 40˚C (cSt)	4.59	5.16	_
Flash point (˚C)	56	176	_
Calorific Value (kJ/kg)	44146	39345	36540
Density (kg/m³)	827	860	0.68

Table 1: Properties of fuels.

C. Composition of CBG

Composition	% Volume
CH_4	89
H_2S	1.5
CO_2	8
N_2	1.5

Table 2: Composition of CBG.

D. Experimental setup

Fig 2 & 3: Computerized diesel engine setup.

E. Engine specifications

Engine Parameters	Specifications
Type	TV1 (Kirloskar make)
No of cylinders	Single cylinder
No of strokes	Four stroke
Rated power	5.2 kW at 1500 RPM
Bore x Stroke	87.5 mm x 110 mm
Compression ratio	17.5 : 1
Injection timing	27° bTDC
Dynamometer	Eddy current

Table 3: Engine specifications.

The experiment was carried out to investigate the exhaust gas recirculation on the performance and emission characteristics of CI engine fuelled with diesel – compressed biogas and ROME – compressed biogas in a stationary single cylinder diesel engine. Technical specifications of the engine are given above. The engine was coupled with eddy current dynamometer. The performance and emission parameters were analyzed from the graphs regarding brake thermal efficiency, HC, CO, NOx, smoke opacity. Exhaust gas analyzer and smoke meter are used for measuring emissions. EGR can be increased from 5% to 10% to study the performance and emission parameters.

3. Results and discussion

A. Brake thermal efficiency

Fig 4 & 5 shows the variation of BTE vs. EGR at 80% and 100% load respectively. BTE increases with increase in EGR rate. The reason for increase in BTE with EGR is due to re-burning of HC that enters combustion chamber with the recirculation of exhaust gases and also EGR increases intake charge temperature which increases the rate of combustion.

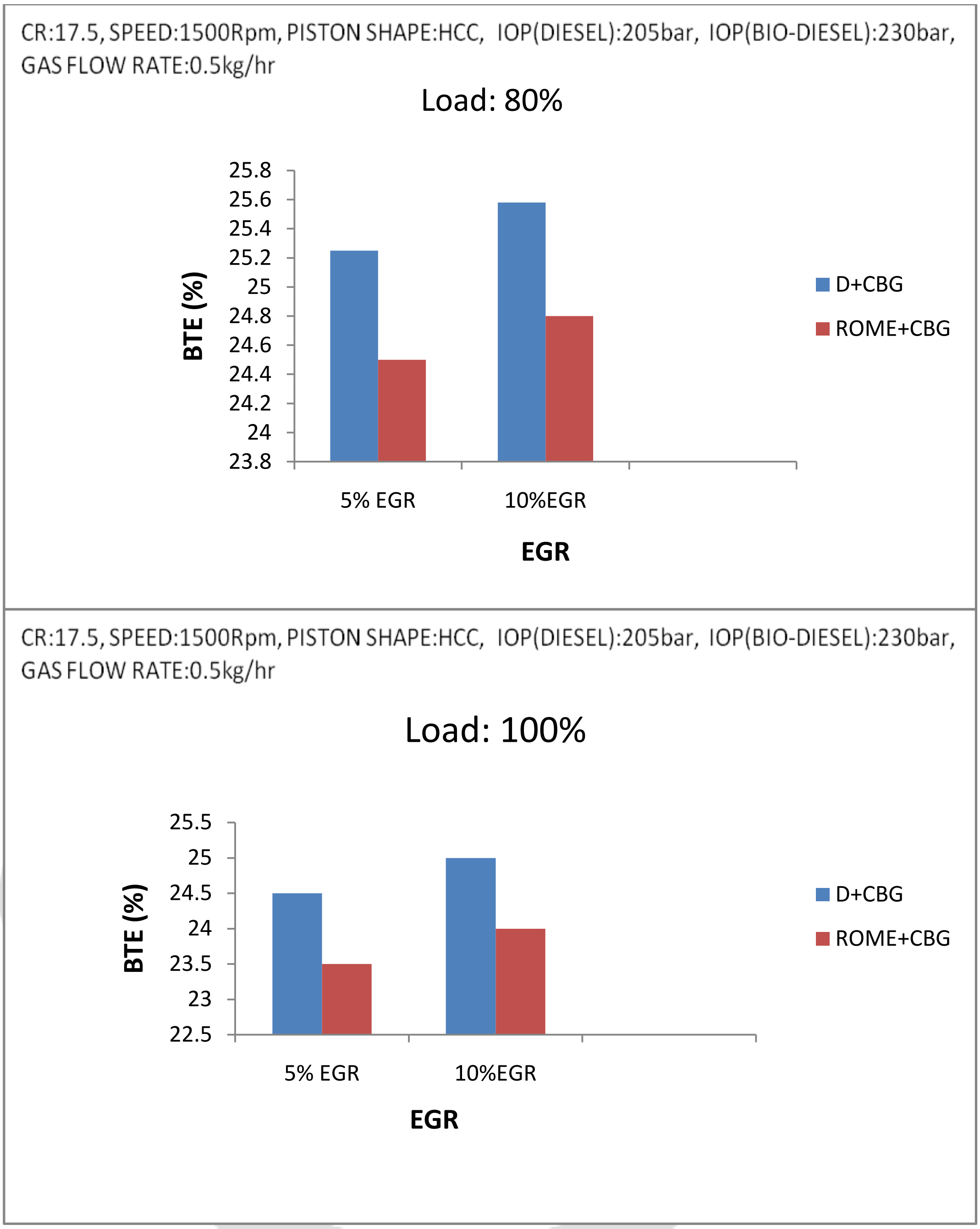


Fig 4 & 5: Variation of BTE vs. EGR at 80% and 100% load respectively.

B. HC emission

Fig 6 & 7 shows the variation of HC emission vs. EGR at 80% and 100% load respectively. HC emissions are increases with increase in load and EGR rate. This is due to 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.

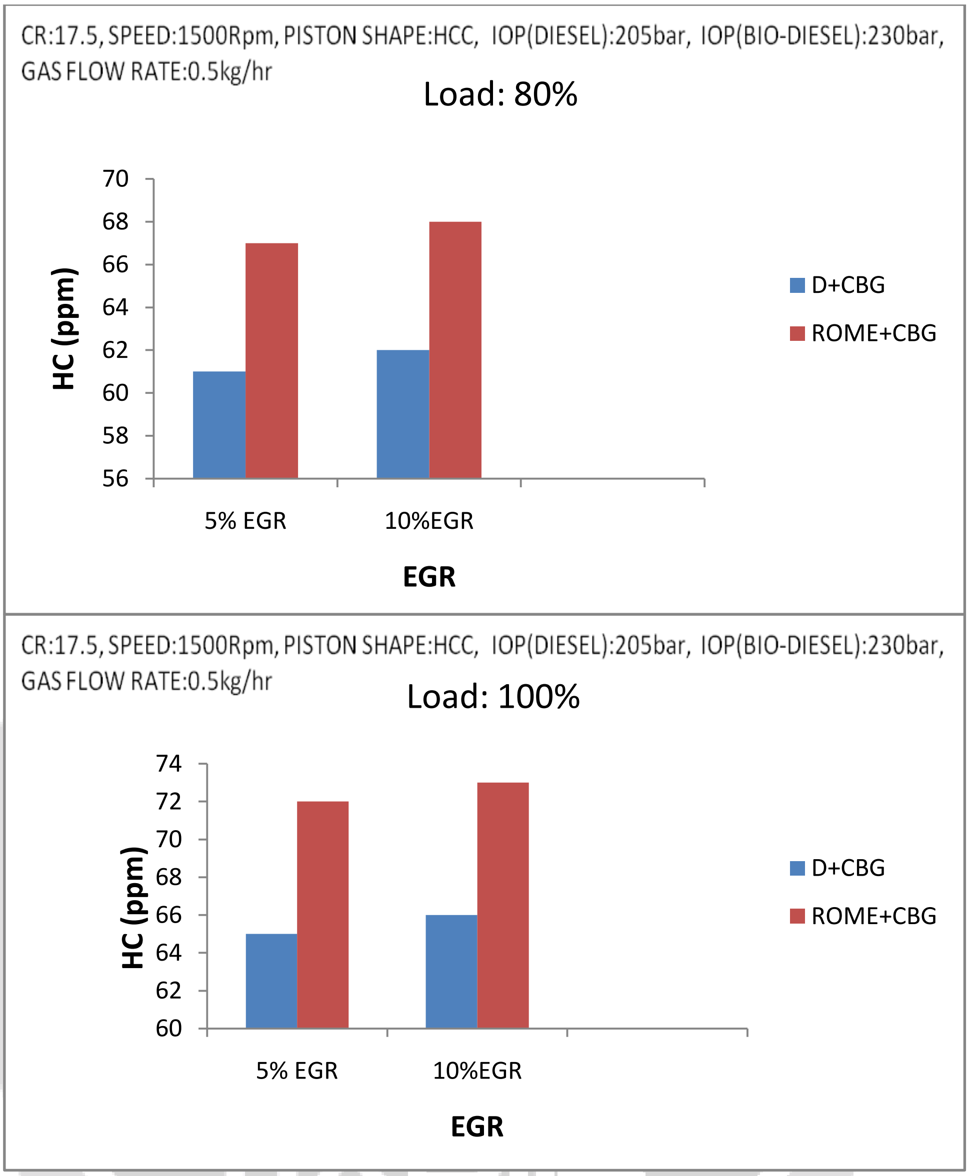
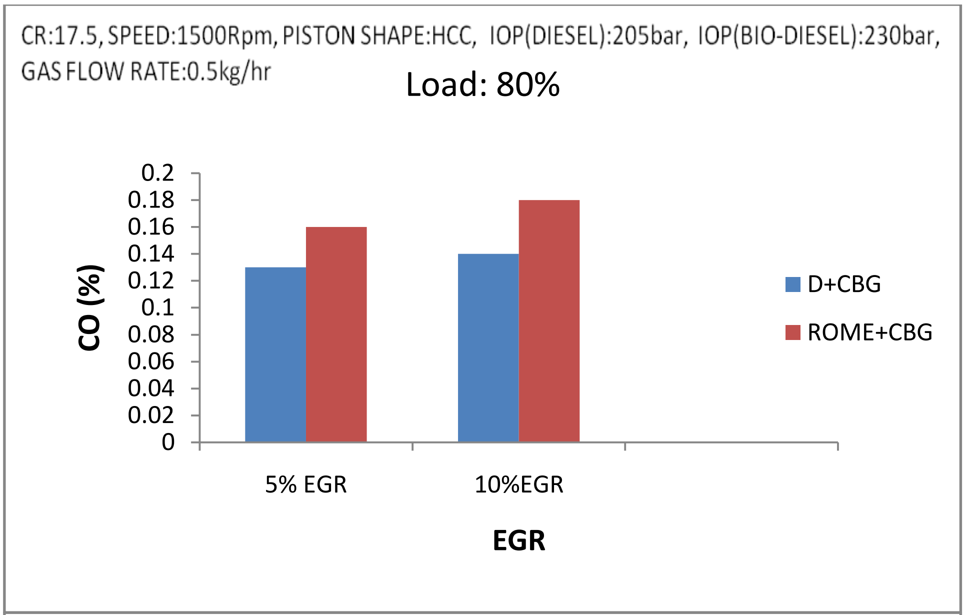


Fig 6 & 7: Variation of HC emission vs. EGR at 80% and 100% load respectively.

C. CO emission

Fig 8 & 9 shows the variation of CO emission vs. EGR at 80% and 100% load respectively. The CO increases with increase in load and EGR rate. The deficiency of oxygen with the increase in EGR percentage can be attributed to the rapid growth of CO at initial stages of the EGR. However the excess oxygen content in biodiesel can compensate for the oxygen deficient operation under EGR.



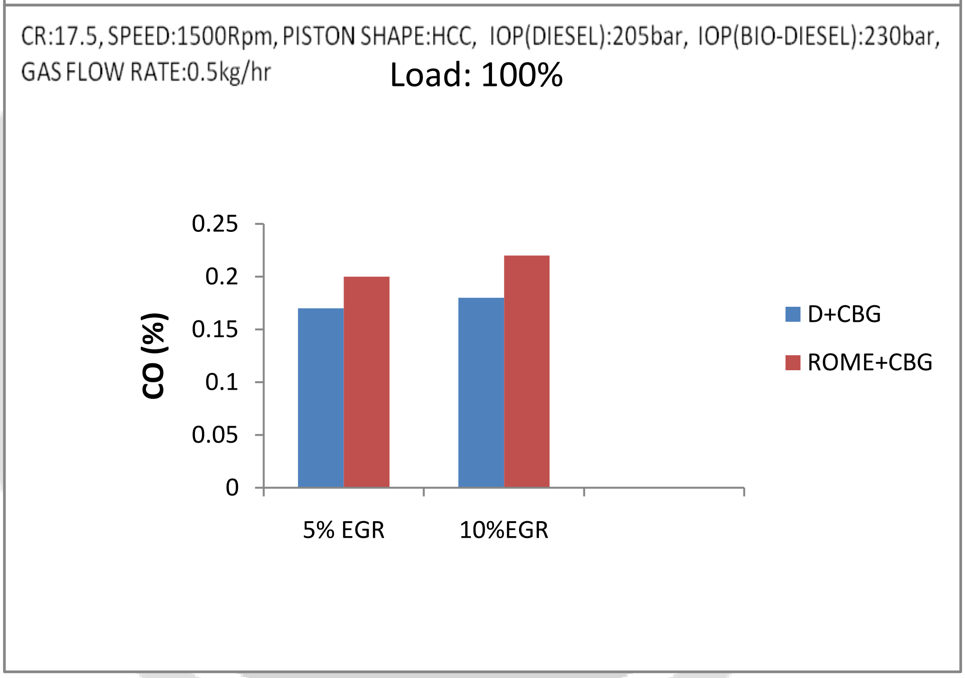


Fig 8 & 9: Variation of CO emission vs. EGR at 80% and 100% load respectively.

D. NOx emission

Fig 10 & 11 shows the variation of NOx emission vs. EGR at 80% and 100% load respectively. NOx decreases with increase in EGR rate. The reason for reduction in the NOx with EGR is that, reduction of the combustion temperatures as a result of the addition of exhaust gases to the intake air which increases the amount of combustion accompanying gases mainly CO_2 which reduces the combustion temperature.

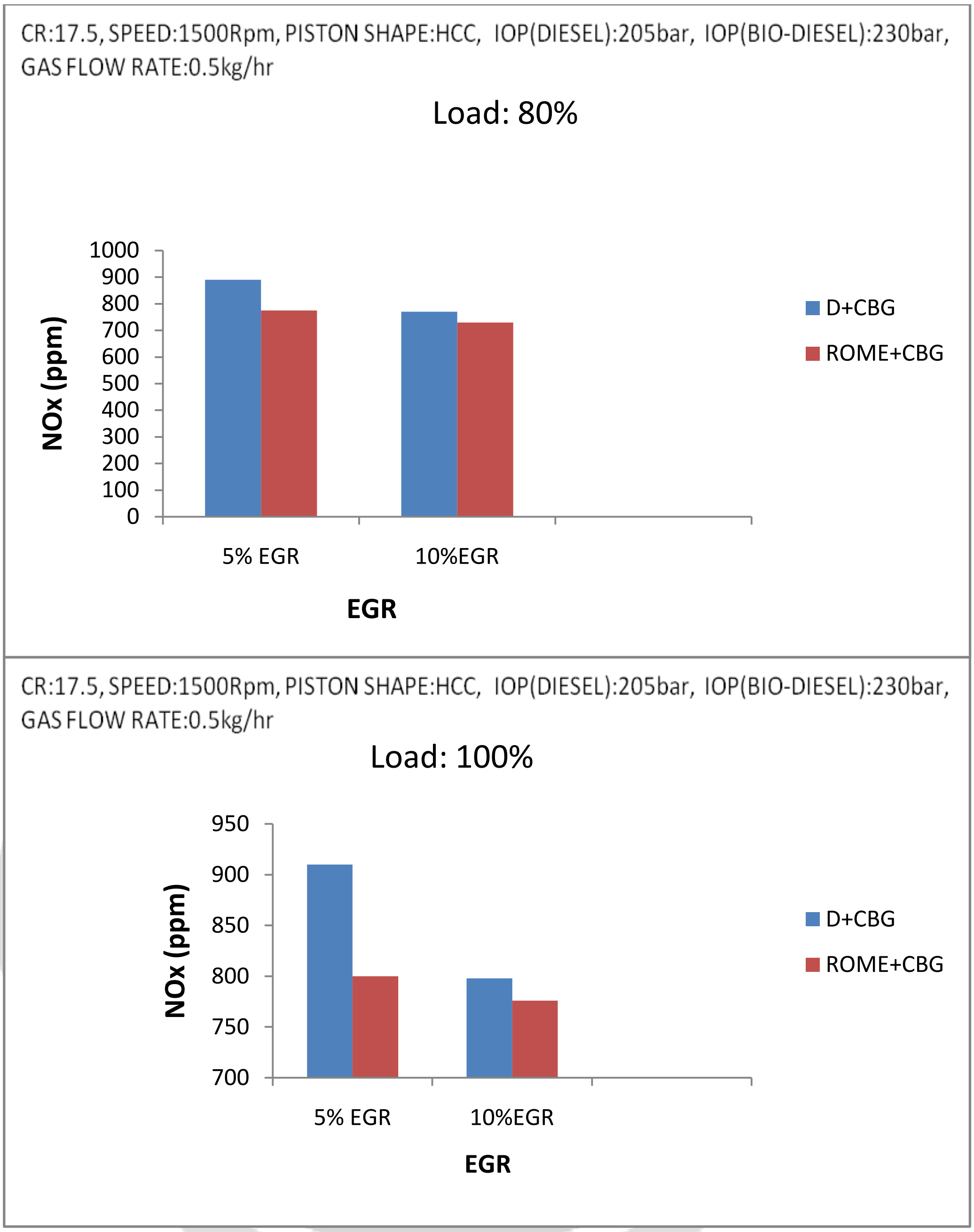
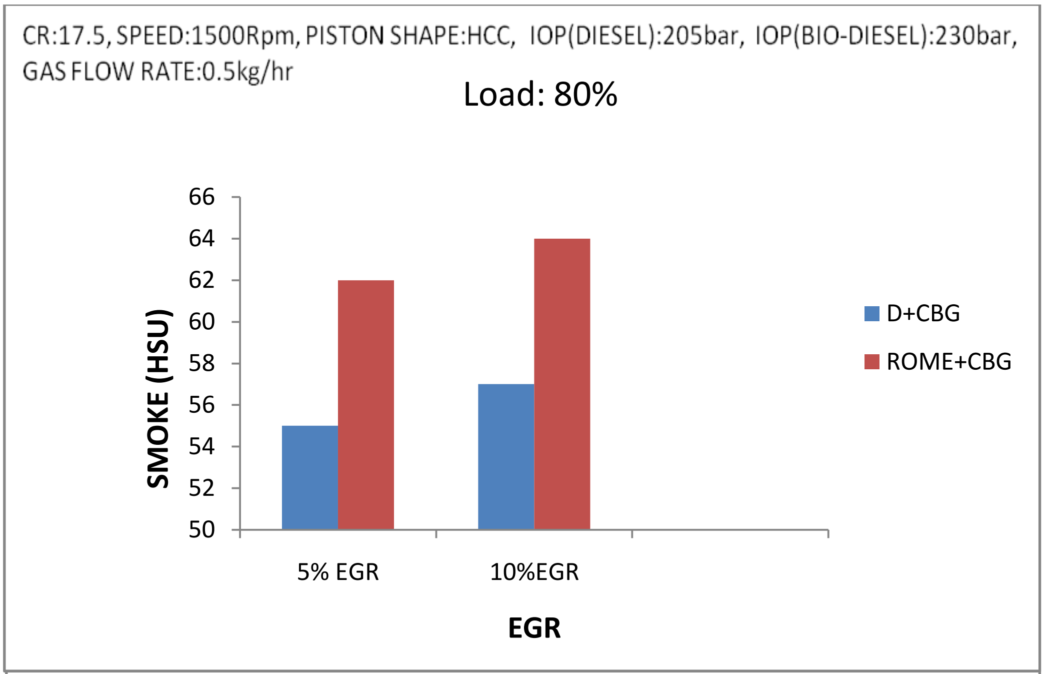


Fig 10 & 11: Variation of NOx emission vs. EGR at 80% and 100% load respectively.

E. Smoke opacity

Fig 12 & 13 shows the variation of smoke opacity vs. EGR at 80% and 100% load respectively. The smoke increases slightly as the EGR rates increases. This is because of the recirculation of exhaust gases into the cylinder.



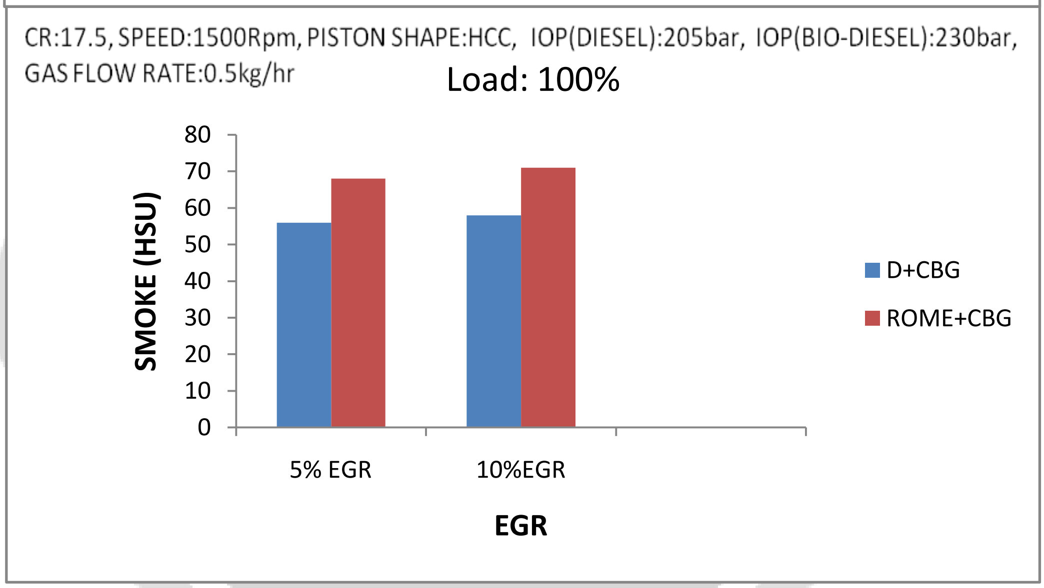


Fig 12 & 13: Variation of NOx emission vs. EGR at 80% and 100% load respectively.

4. Conclusion

The following conclusions can be derived from the present experimental investigation,

- The effect of EGR can be found predominant in reduction of NOx emissions.
- There is a slight increase in brake thermal efficiency of engine due to EGR.
- HC emissions are increases with increase in EGR rate.
- The CO increases with increase in EGR rate.
- Smoke increases slightly with increase in percentage of EGR.

So taking all the results into consideration from the present experiment, EGR with 10% exhaust gas recirculation would result in optimum engine performance as well as reduction of NOx emissions and considerable values of other emissions.

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