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# Emission and Performance Analysis of Green Gas in a VCR Engine

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The current advancement in producing the organic-based fuels, the gaseous fuel such as Green gas promises to be used in the vehicular engine. The gasification technique is used to gasify biomass such as rice husk, bagasse, wood chips resulting in production of organic green gas. It is prepared by gliding air and steam through the thick coal at different temperature range. Due to inertness, knocking tendency is higher in green gas, use of green gas tends to higher emission of CO, especially at lean condition through gasification technique. In our results of emission analysis, there is significant reduction in $SO_x$ and $NO_x$ from the engine running on green gas dual fuel operation. The use of green gas as an alternative fuel is founded as the sustainable and eco-friendly energy source.

**Keywords:** Green Gas, Gasification, Biomass, Compression Ratio, Emissions, Energy

## Introduction

Main source of green gas are coal, rice husk, charcoal, etc. these solid substance are converted into gaseous form by gasification process by downdraft gasifier. This is basically a thermo chemical process. Pyrolysis is done on high temperatures. Following are the constituents of the green gas are carbon monoxide i.e.CO (17 to 21%), $CH_4$ (Methane 1 to 5 % ) , hydrogen (14 to 18%) , hydrocarbons (HC is 0.3 to 0.5%) , $N_2$ (Nitrogen is 44 to 56%) , $H_2O$ (water vapor is 4%) . Green gas is widely used to generate electric power all over world. By the use of coffee husk, in dual fuel, the diesel is replaced by 31%, this is because of formation of clinkers and low density of the biomass. Dual fuel makes the operation more smooth and quiet. They also results in low emission level (smoke and dust)[1-4]. The average quality of green gas is less than the natural gas and gasoline engines, so the modification are needed accordingly .also the compression ratio of spark ignition engine is very low and low energy density of green gas results in extensive power degradation .the percentage of lost power is almost 30% due to lower energy density and remaining is due to loss of pressure in inlet valves. So modification is done such as advancement of timing of ignition by 30-40 degree and some changes are done with compression ratio and rotational speed of engine. Enhanced compression ratio and low rotational speed in compression ignition engine makes this more suitable for Greengas[5-13].Fossil fuels are commonly used as alternative fuels in transportation as well as power generation. Gaseous fuels results in pollution free combustion. Gasification results in syngas, a gaseous fuel. Downdraft type of gasifier is used due to less tar content. The performance analysis is performed for a heavy-duty with 12 cylinder Internal Combustion engine in this paper. The engine which has been fuelled up with the natural gas, can be specialized to burn a green gas stream which is the output of wood chip's gasification into a downdraft gasifier. Paper's objective is to enhance the limited data of green Gas fuelled medium-size IC Engine emissions characteristics with the performance and to give a general procedure to find the efficiency of the engine with some parameters. De-rating of power in green gas engines is mainly due to lesser energy density per unit volume of mixture and decrement in volumetric efficiency. These are founded stable under lean condition. The chemical composition and physio-chemical values of diesel and producer gas is listed in Table 1 and Table 2 below:

Green gas needs 2.5 to 3 kg of wood to make the equal amount of energy as of 1 ltr. diesel. Now a days, need of fuel is very large in every sector like agriculture, transportation, etc. but the manufacture does not able to match the requirement. India has a significant amount of land for agriculture, by this it produce about 60 million tons of fuel from biomass.

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Table 1 — Generalized diesel properties

| Properties | Diesel |
|---|---|
| Density in kg/m3 | 842 |
| Calorific Value in kJ/kg | 42.8 |
| Flashpoint in $^{o}$C | 76 |
| Cetane Number | 43-51 |

Table 2 — Composition of the Green gas

| Item | Composition (%) | Composition (average) (%) |
|---|---|---|
| CO | 18-22 | 20 |
| $N_2$ | 45-55 | 60 |
| $H_2$ | 15-19 | 17 |
| $CH_4$ | 1-5 | 2.5 |
| Calorific Value | -- | 4.5MJ/Nm3 |

## Experiment Setup

The gasifier, a naturally-aspired ICE and a gas cleaning unit these are constitute of a biomass power plant and these constitute is also operate in the combined power and heat mode as shown in Figure 1. The gasifier is used in this experiment is directly coupled to 150 KW power units and the name of gasifier is typical closed-top fixed-bed downdraft gasifier. We introduced the biomass through the top of gasifier. With the help of blower the combustion zone is inflated with the gasification air, after that green gas is preheated. After that there is a cleaning unit in which green gas is scrubbed to remove tar and other particles by the help of sequential filters. Before passing through the ICE the PG is passing through the gas-water heat exchanger which is cooled up to 70(degree C). The technical engine specification are listed in Table 3.

## Results and Discussion

The analysis of this fuel is performed on the basis of exhaust emissions and brake specific fuel consumption

### Exhaust Emission

Figure 2 shows the variation of exhaust emission in diesel mode and dual fuel mode at different compression ratio. The Exhaust emission shows the maximal amount of emissions of NOx of the exhaust gas in the diesel mode was observed to be 396 ppm. But in diesel fuel mode NOx emission is in Between 13 to 80ppm. But it is seen that in diesel mode the NOx emission came 36% to 57%approx maximal when operated with diesel-green gas mode at 3.2KW BP and it is seen that the concentration of CO emission was 81% to 84% maximal indiesel-green gas

Fig. 1 — Experimental setup in Engine research Lab

Table 3 — Specification of VCR Engine

| Parameter | Specification |
|---|---|
| Type | Four stroke One cylinder, water cooled ,Multi-fuel VCR |
| Stroke | 11 cm |
| Bore | 8.75 cm |
| Capacity of Engine | 661cc |
| Power | 3.5KW |
| Engine RPM | Approx. 1500rpm |
| Compression Ratio | From 12 to 18 |
| Variation in injection | Nill to 25 degree BTDC |

mode than just diesel fuel mode at 3.2KW BP. The trend of the graph in the emission research analysis states that when the blend of diesel and green gas is used, the emissions of CO will decrease in comparison to CO emissions of neat diesel on the increase in load. This is due to the reason that when the load is increased, more combustion is required and as the content of green gas is increased, more supply of oxygen is available to assist the combustion process and leads to complete combustion which in turn reduces the CO emissions. This is occur due to increase in load the extra fuel is required, as a result richer air-fuel mixture enter in the cylinder so lesser amount of CO emission is produced due to richer mixture for the complete combustion. It is also seen in the diesel-green gas mode that the hydrocarbon emission came out 62.57% to 71 % that is quiet high than the diesel operation. In both modes of engine operation at higher compression ratio, it is decreases. At the end of the compression stroke the temperature and pressure is high due to high compression ratio. So, better combustion of fuel is shows due to temperature of combustion is higher. From increasing 12 to 18 compression Ratio at 3.2kW BP by this normal reduction of 63.62% in the emission of HC was achieved. In duel fuel mode the emission of Carbon dioxide (CO2) was 6.0% to 33.72% is higher

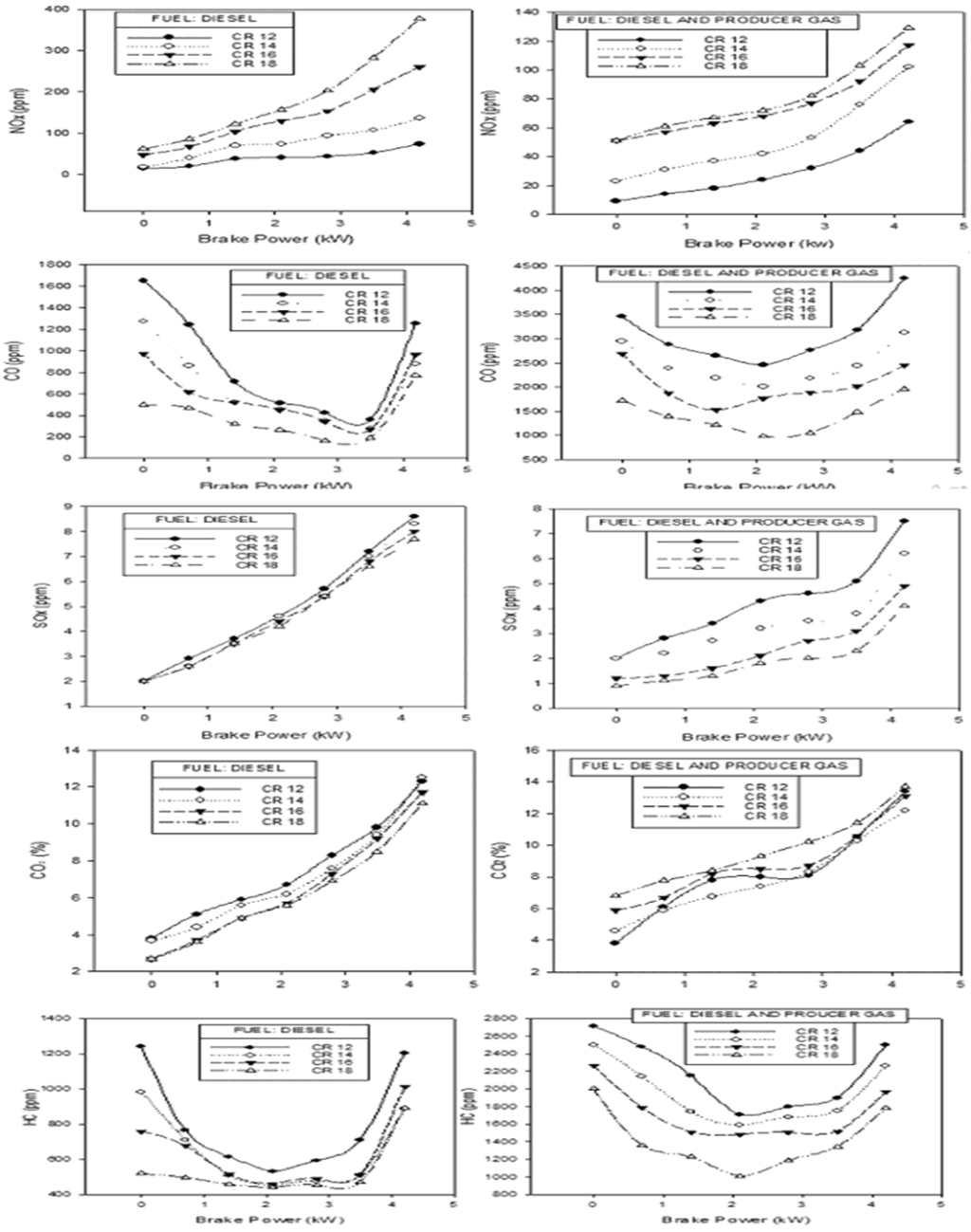


Fig. 2 — Variation of exhaust emission in diesel mode and dual fuel mode at different compression ratio

than diesel mode of BP at 3.2kW. So, due to some amount of CO2 emission is present in green gas is provided to the engine cylinder. So the experiment shows that emission of CO2 is increase due to in compression ratio and load.

**Brake specific fuel consumptions**

Figure 3 shows the variation of Brake specific fuel consumption of the engine at different compression ratio by using neat diesel and its blended form with producer gas. It is observed that at CR 9.7:1 and 17:1 fuel consumption is always higher than that at CR 14. Due to increasing in the engine speed and load the specific fuel consumption was decreased. So, in engine cylinder poor combustion is occurred due to low speed and load. However, increased in the engine speed and load, the value of BSF tended to better because of more absolute combustion. So, in the engine of green gas the specific charcoal intake is minimum at the rate of 0.74kg/kWh were achieved.

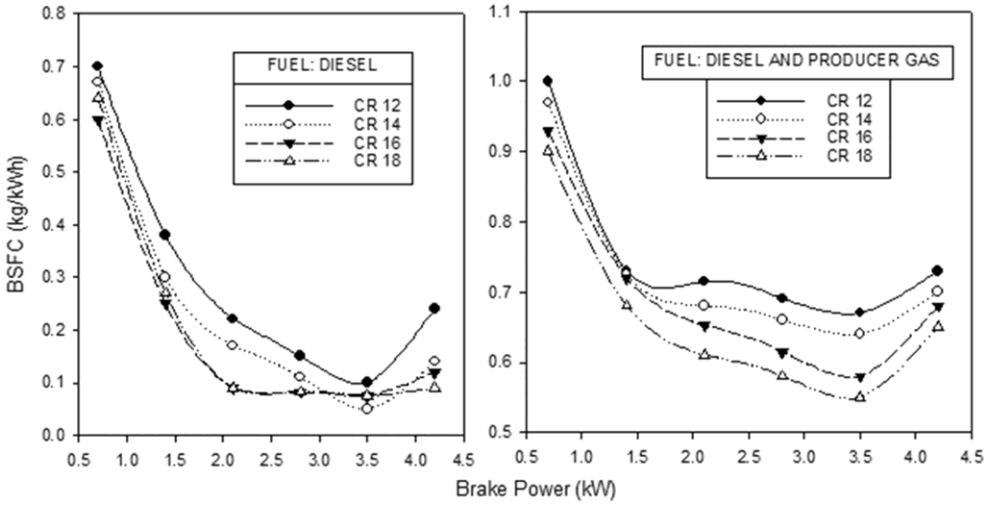


Fig. 3 — Brake specific fuel consumption of the engine at different compression ratio

We can calculated the SEC of the diesel engine and the engine of green gas from the fuel intake of diesel and charcoal with both fuels of calorific value. For both engine the SEC at variable speeds and loads are shown in fig. At every speeds and loads of diesel engine the SEC is lower than that of green gas engine for CR. The SEC is decrease steadily with increasing speed or load of the diesel engine. In green gas engine on comparing between different CRs, minimum SEC was occurred at CR of 14:1. So, in green gas engine the SEC was achieved of 15.07MJ/kWh. At full load and operation at 1700rpm the value of SEC of green gas engine is higher than diesel engine by 11.3%. Due to constituent like energy of volumetric efficiency and fuel mixture in engine of green gas the SEC was increased.

## Conclusion

For compression ratio, 17:1 engine will produce a gas that will be free from the knocks tendency. torque and the power de-rating were also observed lesser in case of green gas because of lower energy density of charge over the enhancement of compression ratio, brake thermal efficiency and the sp. energy conservation are been also enhanced. NOx, HC emissions over the usage of dual fuel mode is low, but CO2 emissions are more. Compression ratio experiences an inverse effect on the CO emissions. In case of noise pollution dual fuel mode had an advantage over diesel mode as it produced lesser noise pollution .operating over compress ion ratios 12, 14, 16, 18, maximum diesel saving attained were 8.29, 31.13, 58.87 , 65.47 respectively. From the above paper various things are concluded that for CR17:1 overall efficiency for 17.5kW is 21% and for 21kW this is found to be 31%. With 1200rpm, diesel mode and dual fuel mode engine gives 3% increment in thermal efficiency and for 1400rpm, it is increased by 4%. If we increased flow rate then emission of CO and HC is also increased but by providing sufficient oxygen, CO emission can be reduced. Green gas needs 2-3kg to give equal amount of energy as 1L diesel. Flow rate also enhance the saving of fuel.

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