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Experimental investigation on spark ignition engine using blends of biogas

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Abstract

Biogas from cow dung is one of the best fuel which readily mixes with gasoline yielded less emission and better performance on gasoline engines. In this study an attempt has been made experimentally on gasoline engine operating with enriched and compressed biogas blends B10, B20 and gasoline. It was observed significant increase in specific consumption and reduction in brake thermal efficiency of the engine. Exhaust gas emissions were measured and analysed for hydrocarbons (HC), carbon dioxide (CO_2), carbon monoxide (CO) and oxides of nitrogen (NO_X) at engine speed of 2000 rpm. The concentration of CO, CO_2 and HC emission were found to be decreased and reverse the case NOx for biogas blends.

Keywords: biogas; emission; blends

Nomenclature

B10	Biogas 10% by volume
B20	Biogas 20% by volume
BP	Brake power
CO	Carbon monoxide
CO2	Carbon di-oxide
HC	Hydrocarbons

NOX Oxides of nitrogen

SFC Specific fuel consumption

1. Introduction

Depletion and rapid conservation of conventional fuel enforces the humanity to search new fuels for next generation. At the same time the emission from those fuels should abide the laws of emission control. Whenever the fuel consumption at full load condition is low, the emissions are low. Biogas can be utilized as alternative to the conventional fuels. Cow dung can be used a source of production for biogas. Scrubbing process reduces the carbon dioxide and corrosive hydrogen sulphide from the bio gas. Combination of biogas with the gasoline increases specific fuel consumption and also maintains air quality. This experimental work is an attempt made with bio gas blends with gasoline.

2. Literature survey

William Cesar et al. (2018) performed experiments on naturally aspired three cylinder SI engine at 1500rpm using Biofuels Bio60 (60% methane) and Bio95 (95% methane, 5% CO2), as well as mixtures (blends) with 20% (vol.) H2, named HBIO60 and HBIO95. It was pointed that the specific fuel consumption of the engine was reduced by 20% for the Bio 95 fuel. Lowest value of CO emission were observed at high load due to complete burning of fuel. At stoichiometric condition high emission of NOx was observed for the same fuel proportion. Eui-Chang Kwon et al. (2016) examined the performance on small SI engines less than 5 kW for compression ratios 8.01:1 to 9.22:1 using biogas gasoline blends. They found enhancement of brake power, brake thermal efficiency and specific fuel consumption when the control volume was reduced from 19.3cc to 16.6 cc.

Shadwal (2016) studied the effect of biogas mixed with gasoline on commercial four stroke SI engine. It was observed 20-30% increase in brake thermal efficiency, 20% and 80% decrease in HC and CO emission and 13% increase in NOX emission at full load condition. Awogbemi et al. (2015) performed experiments on Honda GX 140 si engine using 20:80 biogas petrol blend observed more generation of torque, indicated power and brake thermal efficiency with less specific fuel consumption and exhaust temperature. Porpatham et al. (2011) conducted experiments on biogas fuelled single cylinder spark ignition engine for different compression ratios 15:1 and 9.3:1 at 1500 rpm operated with 25% and 100% throttle opening. It was concluded that the peak power output was 4.8 kW, 10% higher for compression ratio 15:1 than the 9.3:1. The peak brake thermal efficiency increases 5% from 23% to 28% for compression ratio 15:1. Changwei Ji et al (2009) perfumed experiments on 1.6L si engine runs at 1400 rpm with biogas found decrease in CO and HC emission and increase in HC emission at full load condition

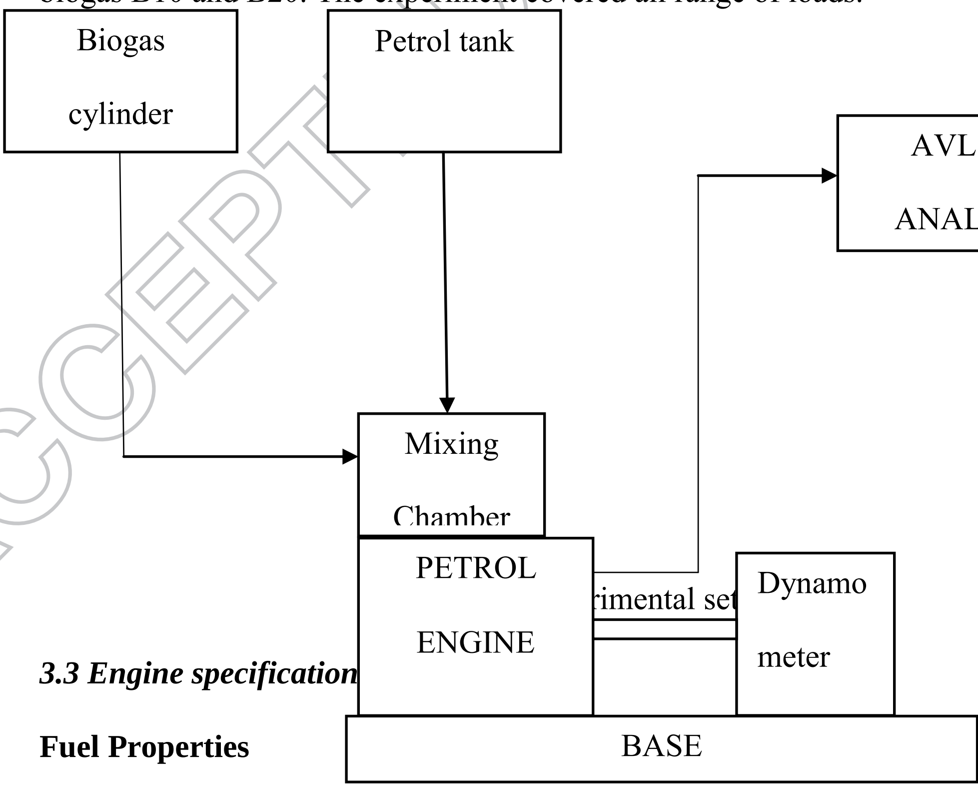
3. Materials and Methods

3.1 Production of biogas

Bio gas production was from the cow dung and the impurities were removed by passing through the lime water at high pressure. CO_2 and H_2S were removed by scrubbing process. The gas was stored in the cylinder for supply. The gas was regulated manually and entered into the mix chamber to get correct proposition.

3.2 *Experimental set up*

The main objective of the work was focused on the study of performance and emission characteristics of SI engine using the biogas blends. Engine was loaded with dynamometer and emissions were measured by using AVL exhaust gas analyser as shown in fig 1. Experiments were conducted with pure gasoline, and the blends of biogas B10 and B20. The experiment covered all range of loads.



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3.3 Engine specification

Fuel Properties

Properties	Petrol	Enriched Biogas
Chemical formula	C_8H_{18}	CH_4- 92 % ,CO_2 -8%
State	Liquid	Gas
Lower heating Value (kJ/kg)	44000	42620
Octane rating	88-100	120-130
Cetane rating	-	--
Auto ignition temp.(K)	257	650-750
Stoichiometric ratio	14.7	17.2
Flash Point ° C	-42.77	-
Freezing Point ° C	-43	-
Boiling Point ° C	187-343	-82 to -161
Latent heat of vaporization kJ/kg	349	-
Density at 150 C, (kg/m3)	720	0.9
Flame Speed (m/s)	04-6	0.34
Flammability Limits (volume % in air)	1.4-7.6	5-15

Engine Specifications

Engine used	188F Honda
No of cylinder	1
fuel	petrol
Engine speed	3600 rpm
Bore	88 mm
Stroke	64 mm
Compression ratio	8:1
Cooling	Air
Power	7.8kW

4. Results and discussion

The performance and emission tests were conducted with blends of biogas B10, B20 and compared with results of gasoline.

4.1 Specific fuel consumption

The profile of Specific fuel consumption increases with increase in the blend composition with biogas depicted in Figure 2. The negative gradient was observed in SFC for B10, B20 and gasoline when the load on the engine was increased. The physics behind the mechanism was the reduction in heat loss occurred due to increase in load. The deviation was less at low loads on the engine for B10 and B20 blends of biogas compared with gasoline at high loads.

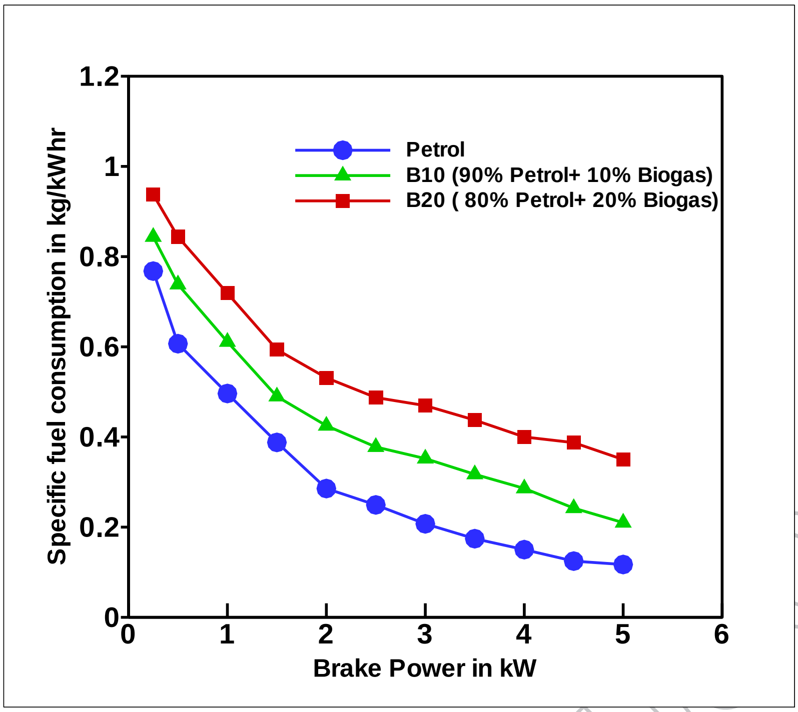

Fig 2. Brake Power vs. Specific Fuel Consumption

4.2 Brake Thermal efficiency

The rise in load on the engine improves brake thermal efficiency for gasoline and blends B10 and B20 is shown by Figure 3. The brake thermal efficiency of B20 was decreased with the load better than B10 and petrol. The reason was the decrease in heating value of fuel when blends with biogas proportion. It is observed that B10 has higher efficiency than B20 at higher loads on Gasoline engine.

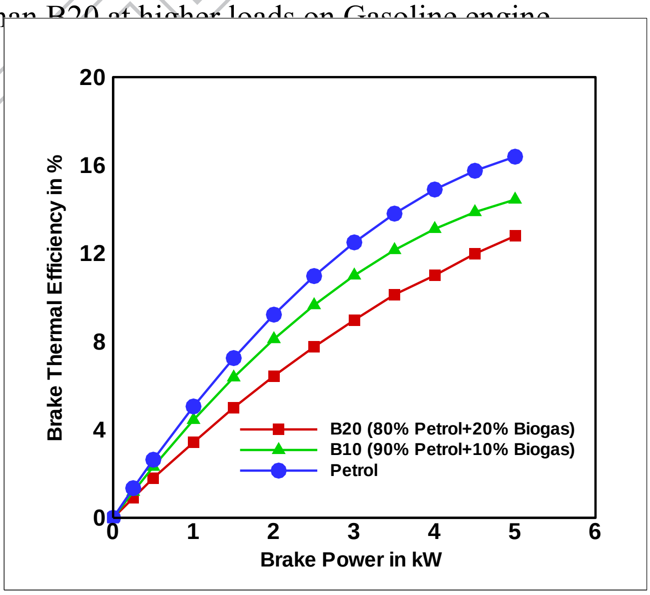

Fig 3. Brake Power vs. Brake Thermal efficiency

4.3 CO emission

The out come of the experimental results were shown in Figure 4 for CO emission. It was observed whenever the mix proportion increase it yields better reduction in the emission of carbon monoxide at higher brake power. It was almost nearly less than 25% at maximum power at higher power compared with gasoline.

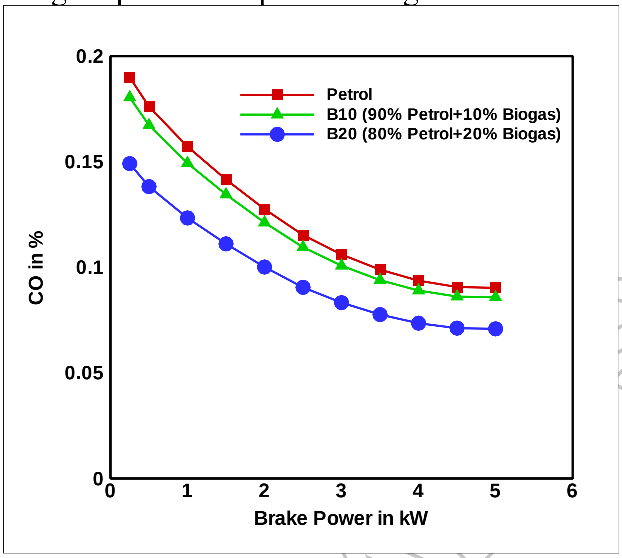

Fig 4. Brake Power vs. CO in %

4.4 HC emission

HC emission was lowered in biogas blends in comparison with gasoline observed from fig 5. This is due to complete burning of biogas blends increases with increase in load reduces hydrocarbon emission. The HC reduction in B20 was 18% lower than gasoline at maximum Load

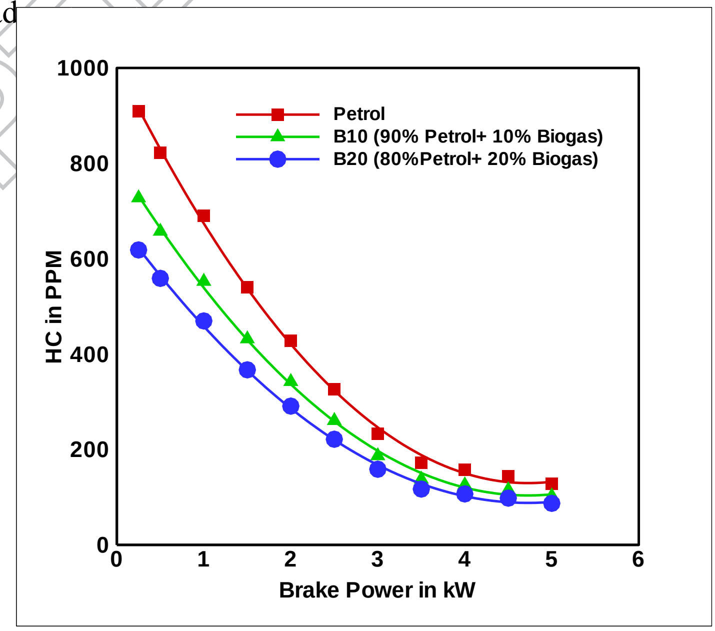

Fig 5. Brake Power vs. HC Emission

4.5 CO_2 emission

The CO_2 emission comparison was depicted in Figure 6. It was observed B10 has better than gasoline and B20 mix. B20 has almost linear relation with brake power. This was due to complete co

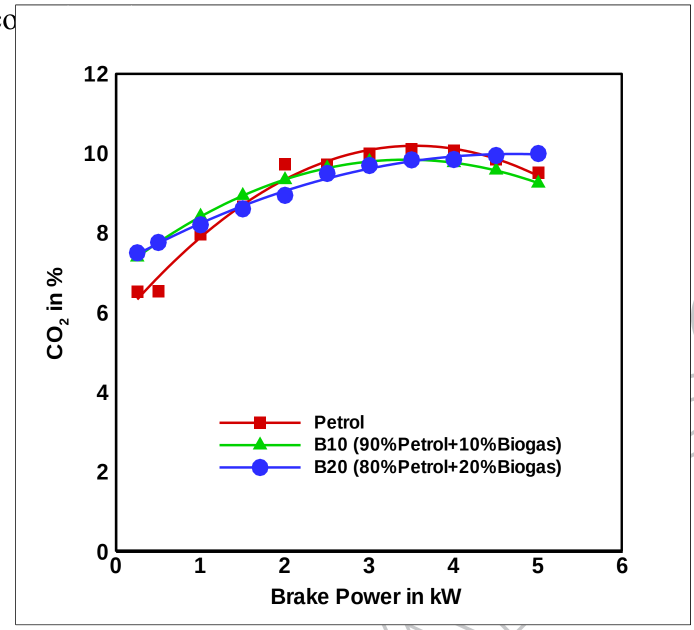

Fig 6. Brake Power vs. CO_2 Emission

4.6 NO_X Emission

The profiles of NOX for the three different fuels were depicted in fig.7. High flame temperature and oxygen absorption during combustion are major factors for emission of NOx. More flame temperature releases more NO_X emission. B20 blend release more NOx at maximum

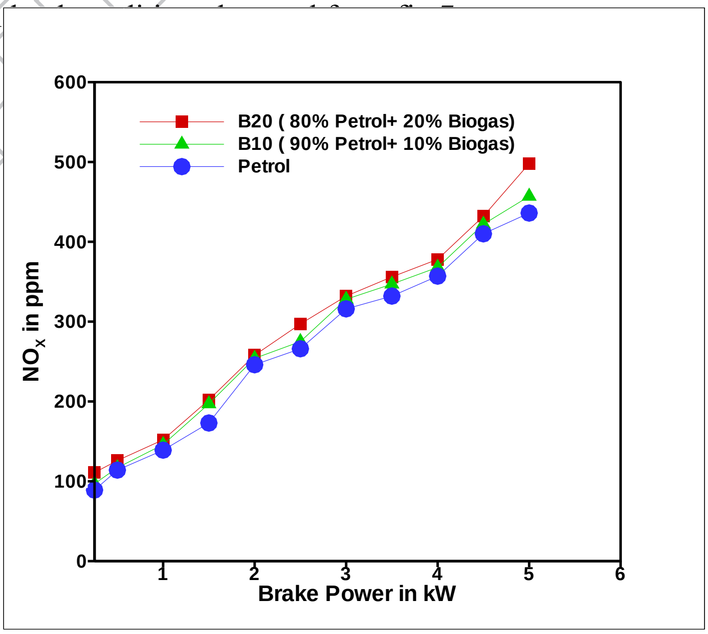

Fig 7. Brake Power vs. NO_X Emission

5. Conclusion

The conclusions were summarised for single cylinder petrol engine are listed below.

- Biogas blends can be used in petrol engine with slight modification.
- B20 blend has better efficiency than B10 blend and Petrol.
- HC and CO_2 emission is lower for B20 blend
- CO emission for B20 has lower for less load and higher for maximum load condition than other fuels.
- NO_X emission found more in B20 blend at maximum load.

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