An Experimental Study of Petrol Engine Using Compressed Biogas as a Fuel

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Abstract—Man in his lifetime, uses energy in one form or the other. In fact whatever happens in nature, results, out of the conversion of energy in one form or the other? The blowing of the wind, the formation of the clouds and the flow of water are a few examples that stand testimony to this fact. Of late, erratic and perfunctory usage of energy has resulted in an energy crisis, and there is a need to develop methods of optimal utilization, which will not only ease the crisis but also preserve the environment. This project attempts to show how man has been utilizing energy and to explore prospects of optimizing the same. Researches show that the world has already had its enough shares of its energy resources. Fossil fuels pollute the environment. Nuclear energy requires careful handling of both raw as well as waste material. The focus now is shifting more and more towards the renewable sources of energy, which are essentially, nonpolluting. The main sources of renewable energy in India are biomass, biogas, solar, wind and hydro power. Biogas is an attractive source of energy for rural areas. It can be produced from cow dung and other animal waste and also from plant matter such as leaves and water hyacinth – all of which are renewable and available in the countryside. Also called ‘‘gobar gas’’

Keywords-BioCNG, Multi cylinder petrol engine, Performance, Emission

I. INTRODUCTION

Biogas is an environment friendly, clean, cheap and versatile fuel. Biogas is produced by anaerobic digestion of degradable wastes such as cattle dung, vegetable wastes, sheep and poultry droppings, municipal solid waste, sewage water, land fill etc. Presently the biogas is mainly used for cooking and lighting purposes in the rural areas. The use of biogas in stationary engines used for different agricultural operations is going on. Its utilization is also feasible in automobiles, used for transportation purposes by enriching and compressing it in cylinders. Biogas can be converted in bio CNG after enrichment and bottling. It becomes just like CNG.Biogas comprises of 60-65% methane, 35-40 % carbon dioxide, 0.5-1.0 % hydrogen sulfide and rest of water vapor. It is almost 20% lighter than air. Biogas, like Liquefied Petroleum Gas (LPG) cannot be converted to liquid state under normal temperature. Biogas contains a large proportion (about 40 % by volume) of carbon dioxide, a heavier and noncombustible gas and some fraction of hydrogen sulfide. Hence it is needed to enrich biogas by removing these undesirable gases to save compression energy and space in bottle and corroding effect, which can be done by a) scrubbing. b) Using carbon molecular sieves. Biogas can be used for all applications designed for natural gas, assuming sufficient purification. Already, CNG technology has become easily available and therefore, bio-methane (enriched biogas) which is nearly same as CNG, can be used for all applications for which CNG are used. A variety of processes are available for enrichment i.e. removing CO_2, H_2S and water vapour. Commonly CO_2 removal processes also remove H_2S. One of the easiest and cheapest methods involves is the use of pressurized water as an absorbent liquid. In this method, the biogas is pressurized and fed to the bottom of a scrubber column where water is sprayed from the top. In counter currently operated absorption process, the carbon dioxide and hydrogen sulfide present in the biogas is absorbed in down going water and methane goes up and collected in vessel. However, water requirement in this process is high but it is the simplest method of removing impurities from biogas. So pressure swing adsorption technique in which water and power requirement is less is becoming more popular these days for biogas purification.

II. EXPERIMENTAL WORK

A. *Equipments*

- Engine: Maruti Suzuki esteem / 4 cylinder / vertical petrol engine with provision to cut off ignition to each cylinder.
  - Make: Maruti Suzuki
  - Bore: 68.5 mm
  - Stroke: 72 mm
  - Capacity: 1298 cc
  - Speed: 1500 rpm
  - BHP: 10 HP
  - Fuel: Petrol
- Rope brake dynamometer coupled to the engine.
- Measurement of Fuel consumption (burette for petrol and Weight Bridge for CNG)
- Cooling water arrangement for engine and dynamometer.
- Air tank with an orifice and water manometer for measuring air intake.
- Speed sensor for measuring speed.

B. *Specifications Of Engine Test Setup:*

No. Of cylinder n= 4
Orifice diameter $d_0=25*10^{-3}$ m
Brake drum diameter $D=200*10^{-3}$ m
Belt thickness $d=7.5*10^{-3}$ m

C. *Properties Of Purified Compressed Biogas*

Carbon dioxide (CO_2) =2.3%
Oxygen (O_2) =5.1%
Methane (CH_4) =90.3%

Fig.1Four stroke multi cylinder petrol engine test rig with rope brake dynamometer

D. Values (For Air, Water, Petrol, Compressed Purified Biogas Etc.) Considered For Calculation

Atmospheric pressure Pa=1.01325 bar
Co efficient of discharge C_d=0.6
Density of water ϱ_{water} = 1000 kg/m^3
Density of fuel (petrol) ϱ_{fuel}=750 kg/m^3
Calorific value of petrol C.V. =43448 kJ/kg
Gas constant R=0.287 kJ/kg.K
Compressed Purified Biogas:
CH4 in CBG= 90.3 %,
CO2 in CBG = 2.3%,
Calorific Value of CBG = 41382 kJ/kg. (Calculated considering methane proportion in CBG)

III. Results And Discussion

A. Fuel Consumption

Fuel consumption (FC) variation w. r. t. to Brake power for speed values 1500 rpm is shown in the graph. From graph it can be concluded that, fuel consumption on Petrol mode is less compared to compressed biogas for almost all the cases. This may be due to lower heating value of compressed biogas compared to that of petrol. Lower heating value for compressed biogas is due to presence of methane up to 90.3%. If purity of biogas is higher than its CO_2content will get reduced and CH_4 proportion will increase which will raise its lower calorific value which will result into less fuel consumption.

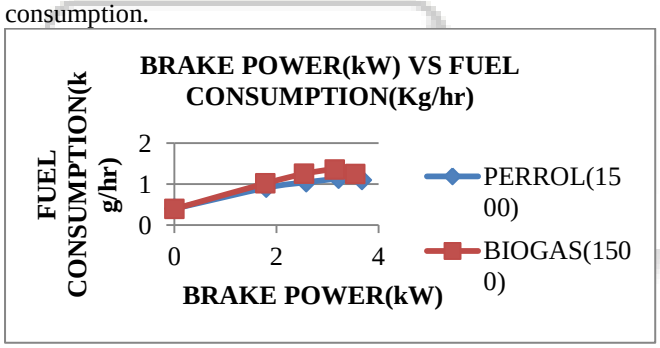

Fig.2 Brake power (kW) vs Fuel consumption (Kg/hr)

B. Brake Specific Fuel Consumption

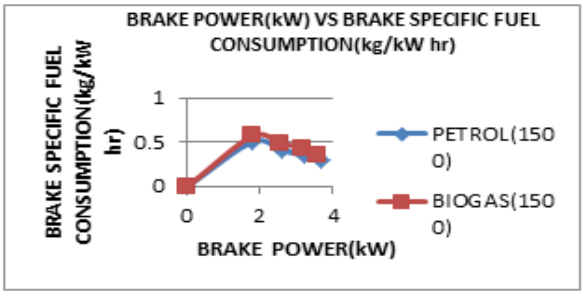

Fig.3 Brake power (kW) vas Brake specific fuel consumption (kg/kW hr)

From graph it can be concluded that for speed 1500 rpm, compared to petrol, brake specific fuel consumption of compressed biogas is higher. This may be due to higher fuel consumption in case of Compressed Biogas which we can say is because of lower heating value of Compressed Biogas (41382 kJ/kg for purity 90. 3 %) compared to petrol (43448kJ/kg).If biogas is treated further to remove its CO_2 content its purity will improve and its calorific value will be considerably higher as compared to petrol. This will result into reduced fuel consumption.

3.3 Brake thermal efficiency

From graph it can be concluded that for speed 1500 rpm v, brake thermal efficiency on petrol mode will be higher compared to compressed biogas for same condition. This is due to higher fuel consumption when compressed biogas is used as fuel. And higher fuel consumption in case of compressed biogas is due to its lower heating value. Based on the result we can say compressed biogas is having good potential to replace petrol.

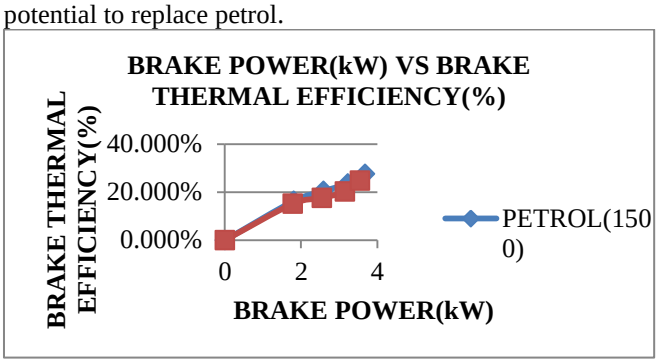

Fig.4 Brake power (kW) vs Brake thermal efficiency (%)

C. Exhaust Gas Temperature

From graph it can be seen that at speed 1500 rpm, exhaust gas temperature of petrol fuelled engine is more for almost all load conditions compared to that of compressed biogas fuelled engine. This is due to lower heating value of compressed biogas compared to that of petrol.

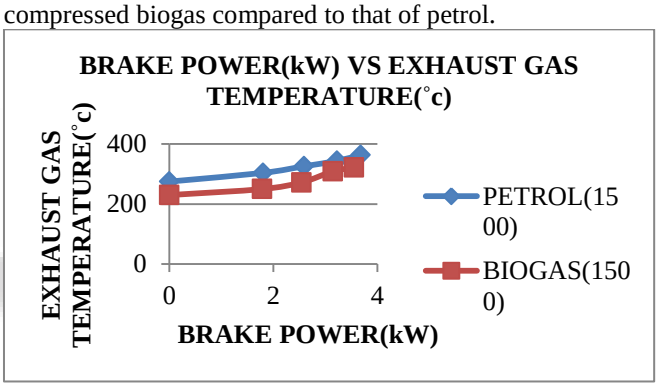

Fig.5 Brake power (kW) vs Exhaust gas temperature(c)

D. Co Emissions

From graph it can be seen that at speed 1500 rpm, value of CO of petrol fuelled engine is higher than compressed biogas fuelled engine at all load condition. So, emission is reduces, when the compressed purified biogas is used as a fuel in auto vehicle engine.

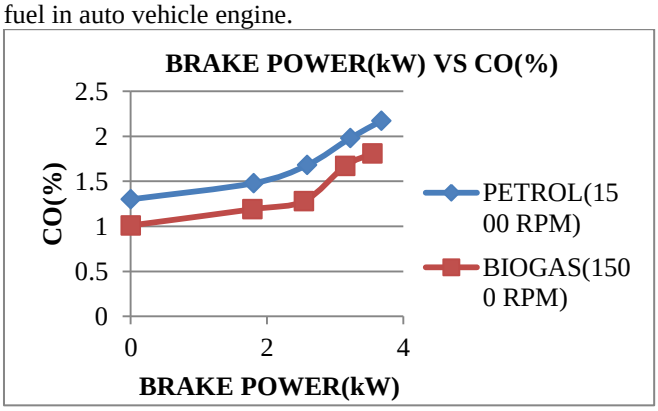

Fig.6 Brake power (kW) vs CO (%)

E. Hc Emissions

From graph it can be seen that at speed 1500 rpm, value of HC of petrol fuelled engine is higher than compressed biogas fuelled engine at all load condition. So, emission is

reduces, when the compressed purified biogas is used as a fuel in auto vehicle engine.

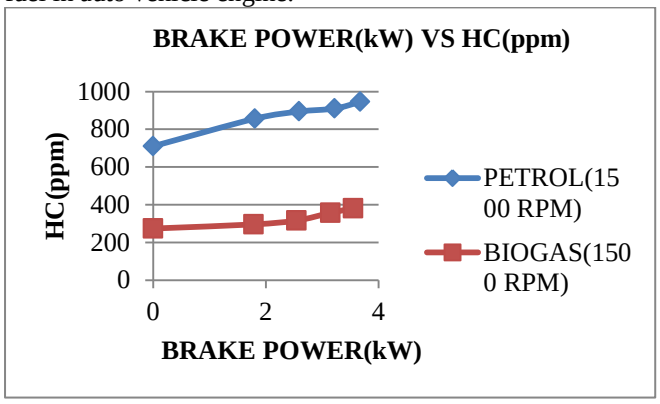

Fig.7 Brake power (kW) vs HC (ppm)

IV. Conclusions

- To use compressed biogas as fuel for automotive engines, commercially available CNG kit can be used without any modification.
- Removal of CO_2 from biogas will increase its methane content which will raise its calorific value. Compressed biogas with purity above 90 % is almost similar to compressed natural gas.
- Engine runs satisfactorily on compressed biogas, considering fuel consumption; brake power produced and brake thermal efficiency.
- Engine produces somewhat less power when run on compressed biogas compared to petrol for same throttle position of fuel supply valve.
- Exhaust emission analysis of petrol and compressed biogas fuelled engine, reveals that unburnt hydro carbons in exhaust of compressed biogas fuelled engine are not significantly higher or lower compared to that of petrol fuelled vehicle. Also carbon monoxide in exhaust of compressed biogas fuelled engine is not significantly higher or lower compared to that of petrol fuelled vehicle. This represents it can replace petrol very easily.
- Engine could be started directly on compressed biogas.

V. Scope Of Work

- Comparison of engine performance and exhaust emissions should be made for fuels like petrol, compressed natural gas and compressed biogas. This will provide information whether compressed biogas can replace compressed natural gas or not.
- Long run engine trials on compressed biogas should be carried out and wear and tear of engine components should be inspected.
- Better purification process be developed to purify raw biogas and engine trial should be taken for engine performance and exhaust emissions.
- Taking engine trial varying Compression ratio for compressed biogas fuelled engine.

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