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Working and Performance Analysis of Gasoline Fuelled Engine with Biogas

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Abstract: *Efficient utilization of biomass is a much needed requirement. A substantial quantity of wet as well as dry biomass in various forms becomes naturally available in the rural areas. It is essential to efficiently utilize the biogas and producer gas. In order to obtain mechanical or electrical power from these gaseous fuels, it is required to develop low-cost technology to convert the existing engines into biogas engines. The gasoline fuelled single cylinder generator engines are well established and available in the market with reasonable priceModificationof internal combustion engines for stationary electrical generators and internal combustion engines was studied. The various blends of L.P.G and Biogas are used and conducted the tests on 4-stroke, singlecylinder, air cooled SI engine. The experimental results were analyzed for the selection of better blendof L.P.G and Biogas suitable for SI engine for better performance with reduced pollution*
Keywords:*biomass, carburettor, renewable, slurry, gasoline.*

I. Introduction

A substantial quantity of wet as well as dry biomass in various forms becomes naturally available in the rural areas. Efficient utilization of biomass is a much needed intervention. Appropriate technologies for waste-to-energy conversion of this resource will go a long way in improving rural economy, ecology as well as energy self-sufficiency. Recycling of moist biomass such as animal and human excreta, domestic as well as agro-industrial organic waste through biomethanation is a highly cherished objective which will have universal applicability in the rural sector. In fact, this conversion process makes available renewable energy in the form of biogas as well as valuable bio-manure in the form of slurry. It improves rural sanitation, promotes the adoption of organic farming and the use of animals more viable economically. In fact, even in the urban sector, such a conversion is becoming inescapable in context with large dairy clusters, poultry and other animal farms, sewage treatment, plants and even in large hotels, hostels, food processing industries etc. where large amount of organic waste is produced and needs to be recycled in an eco-friendly manner.

Petrol is a fossil fuel made from crude oil.The supply of petrol is limited. India ismainly dependent on Arab countries fortheir fuel supplies. The specter ofeconomy ruin due to depleted oil reserveshas changed the interest of scientist andresearch work towards alternative fuels formotor vehicle. While alcohol is used as afuel, it's feasibility as motor fuel dependson the successful cultivation andprocessing of sugarcane. Gaseoushydrocarbons seem to bethe bestimmediate option presently available.These are mainly compressed natural gas(CNG) & liquefied petroleum gas (LPG).LPG is being imported whereas CNG isavailable in abundance in India. India islargest cattle breeding country, there isabundance of raw material for producingbiogas. Also municipal sewage can beused for this purpose. The use of methaneseparated from biogas as a fuel willsubstantially reduce harmful engineemission and will help to keep theenvironment clean. Biogas consists ofapproximately 55-60 % of methane.Biogas can be produced by anaerobicdigestion of organic matter. The rawmaterials for biogas are cow dung.

- To harness the vast availability of Bio-mass in rural parts and to make the Indian villages self-dependent for their energy requirements
- To improve the existing conversion kit for higher range engines.
- To reduce the dependence on scarce fossil fuels for shaft power generation.
- As far as possible, efforts should be made to use standard components, easily available in the automotive engine component market.

Biogas quality varies among the region making it difficult to upgrade it in to the standard state to fuel the engine. As reported by Osorio and Torres [1]biogasis composed of various gases such as methane (60–70%), CO2 (30–40%), nitrogen (<1%), and H_2S (10–2000 ppm). This various composition makes difficult for the user in setting the engine. The concentrations of the impurities (methane, carbon dioxide, water, hydrogen sulfide, nitrogen, oxygen, ammonia, siloxanes and particles) are dependent on the composition of the substrate from which the gas was produced. However, to prevent corrosion and mechanical wear of the upgrading equipment itself, it can be advantageous to clean the gas before the upgrading. When flowing out from the digester, biogas is saturated with water vapour, and this water condensate in pipelines and cause corrosion. Water can be removed by cooling, compression, absorption or adsorption. By increasing the pressure or decreasing the temperature, water will condensate from the biogas and can be removed. Cooling can be simply achieved by burying the gas line equipped with a condensate trap in the soil. Water can also be removed by adsorption using molecular sieves, SiO_2, or activated carbon. Beside its difficulty for fuelling the engine, biogas has advantages as alternative energy since easy to produce even from municipal waste. This make that the effort to use biogas to fuelled the engine should be promoted and supported as what happened in the developed country. The advantages of biogas plants are varied. Economically attractive investment; easily operated and safe installation; production of renewable electricity and heat resulting in a reduction of CO_2 emissions; reduction of methane emissions from manure storage and; improvement of fertilizing qualities of manure. Biogas systems also lead to indirect environmental effects that are not direct results of the replacement of other energy systems. It is reported that by increasing the compression ratio in the spark ignition engine could make possible for the gasoline type fuelled engine to replace by using biogas, but spark ignition engine operation with biogas containing significant fractions of inert gases such as CO_2 and N_2 exhibit decrease of performance compared with natural gas or gasoline. It is likely that emissions of NOx will increase. The idea from Rakopoulos and Michos[2]to make a mixture of 15% hydrogen in to the biogas for fuel the spark ignition engine with result the addition of hydrogen in biogas that promotes the degree of reversibility of the burning process mainly during the combustion of the later burning gas, but the contribution of the early burning gas to the decrease in combustion irreversibility with hydrogen addition seems to be less prominent.

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II. Description Of Experimental Set Up

The schematic of the process by using 100% biogas is presented in Fig. 1. The biogas obtained from digester was desulfurized by using annealed and compacted steel waste chips from the waste of turning process.

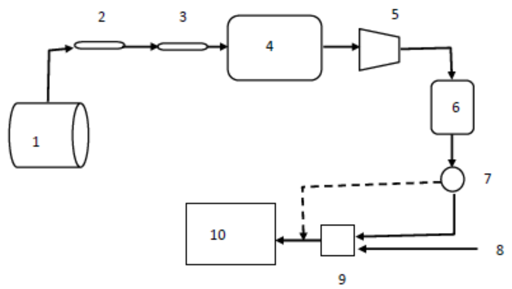


Fig.1. Schematic of conversion method from gasoline to biogas fuelled electric generator engine. 1. Digester; 2.Desulfurizer 3. Dehumidifier;4.Bag of gas holder; 5.Compressor; 6.Gas container; 7.Vaccum opened valve; 8. Air Intake; 9 Biogas and air mixer; 10 Engine.[1]

To ensure that the biogas is free from H_2S impurities, the H_2S content in the biogas was checked before and after passing the desulfurizer. If the H_2S still found in the biogas, the addition of billet of annealed and compacted desulfurizer should be done. The biogas with free impurities of H_2S was flowed to enter the dehumidifier. Again should be ensured here that the biogas should be free from water content. Afterward the biogas was let to flow in to the bag of gas holder, which from here was ready to be compressed in to the biogas container until reach about 6 bar. The valve that will open by vacuum mechanism was installed to arrange the flow of the biogas. With this valve the gas will flow in to the intake of the manifold and will stop if the engine not runs. The biogas then continues to flow in to the mixer part. This mixer component is part of the carburettor in the gasoline fuelled engine but the carburetion cup was replaced and only mixer part is remain. Together with biogas, the air was flowed in to the mixer, and directed in to the intake valve of the combustion chamber. It should be noted here that during starting the engine, the flow rate of the biogas was let maximum and reduce the rate until the engine start running. After that, the rate of air flow in to the mixer was adjusted until the engine run stably. The composition of CO_2 in the biogas was not in to account in this research since the process for purification of biogas from CO_2 contaminant is complicated for implementation as demonstrated by Chien [3] and also TippayawongandThanompongchart [4].This work also can be used as a proof, that the biogas can run the engine even if still contains CO_2 impurity. The detail schematic for the process is provided in Fig. 2. The selected engine for this purpose was 4-stroke gasoline engine, air- cooled, inclined single cylinder. The displacement is 196 cc, with compression ratio 8.5:1. The ignition system was non-contact transistor ignition (TCI). It was planned in this research that will not change the specification of the engine for the easy conversion method from gasoline to biogas. In this research investigation on the effect of mixing biogas with liquefied petroleum gas (LPG) was also conducted. The variations of biogas composition in the mixture of biogas-LPG in this research namely 80%, 85%, 90%, 95% and 100%[1]. The effect of variation of the biogas-LPG mixture on engine speed was then investigated.

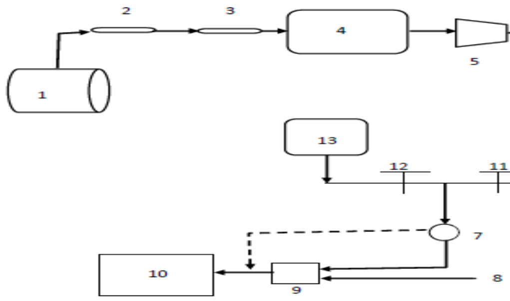


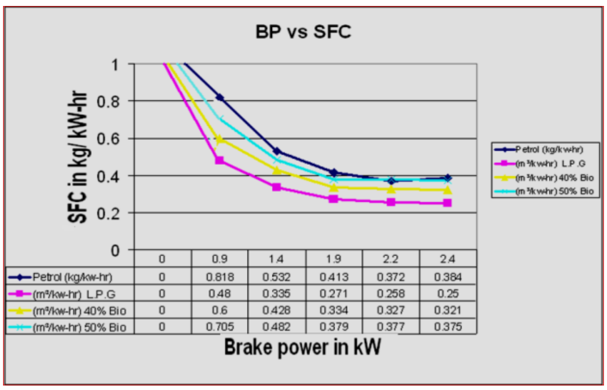
Fig.2. Schematic of conversion method from gasoline to biogas fuelled electric generator engine. 1. Digester; 2. Desulfurizer; 3.Dehumidifier; 4.bag of gas holder; 5.Compressor; 6.Biogas container; 7.vacuum opened valve; 8.Air intake; 9.Gas and air mixer; 10.Engine; 11.biogas valve; 12.LPG valve; 13. LPG container.[1]

The both gas container in the Fig.2have the same initial pressure i.e about 6 bar[1]. The valve 11 at the beginning was let full open and the valve 12 was full closed. The engine was then operated, and the engine speed was measured. The experiment then was continued by making amixture 95%, 90%,85%, and 80% of biogas composition in the mixture by arranging the valve 11 and valve 12 and the engine speeds were measured respectively. The graph of gas mixture composition versus the engine speed was provided.

1. Engine Specifications:
Bhp : 7
Speed : 8000 RPM
Bore : 50mm
Stroke : 60mm
Orifice Dia: 20mm
Compression Ratio : 17.5:1

2. Experimental Procedure :
1. Connect the gas regulator to the gascylinder.
2. Place the gas flow meter betweenthe regulator and gas kit.
3. And check the any leakage from thepipes and tight the pipe clamps.
4. Open regulator valve, gas flows tothe engine.
5. The fan is supplied air to the enginefor cooling.
6. The electrical power is supplied tothe panel instrumentation.
7. Fill up water in water rheostat to arequired height and add salt(approximately 500 gm in filledwater tank).
8. Confirm that the engine in neutralgear, put off main switch of rheostatand ignition switch of engine is'ON'.
9. Press the choke knob and give asharp kick, engine will start. As theengine starts, release the knob andallowed it to run at a rated RPM i.e.7200 RPM, pull the clutch lever andput the engine in 4th gear.
10. Slowly increase the acceleratorand set the generator speed to 900rpm.
11. 11.The engine is loaded by rotatethe knob (on panel) in clock wisedirection so that the engine gets loaded. (take sufficient load)
12. Note down time for 3000 c.c fuelconsumption from the gas flowmeter, ammeter and voltmeter readings.

3. Performance Analysis:
Specific Fuel Consumption:



	0	0.9	1.4	1.9	2.2	2.4
Petrol (kg/kw-hr)	0	0.818	0.532	0.413	0.372	0.384
(m^3/kw-hr) L.P.G	0	0.48	0.335	0.271	0.258	0.25
(m^3/kw-hr) 40% Bio	0	0.6	0.428	0.334	0.327	0.321
(m^3/kw-hr) 50% Bio	0	0.705	0.482	0.379	0.377	0.375

Fig. 3 Fuel Consumption Characteristics

From the figure it is observed thatSFC is maximum at low brake power andis decreasing with increase of brake powerfor all blends of fuel. For a blend of 50%the SFC is same with compare to thePetrol at low brake power values and isvery close to petrol at high values of brakepower. Hence at thoe blend of 40 % ofbiogas the performance of the engine isgood.

Brake Thermal Efficiency:

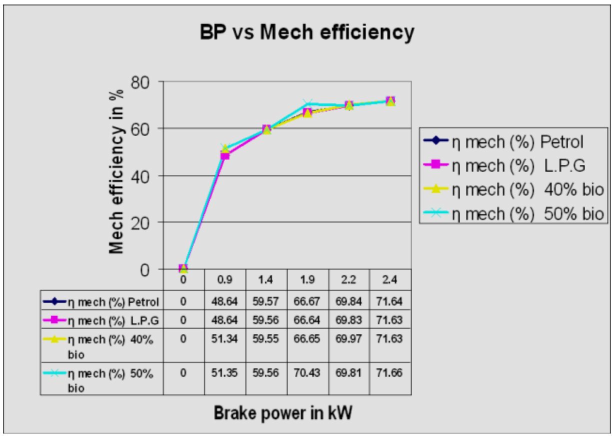


Fig.4 Brake Efficiency Graph.

It is observed from the figurethat the nature of brake thermal efficiencyat all points of brake power for all fuels. Itis also observed that the brake thermalefficiency is higher for the gaseous fuelwith compared to the petrol. It is due tothe high homogenate for gaseous fuel withcompared to the petrol.

Mechanical Efficiency:

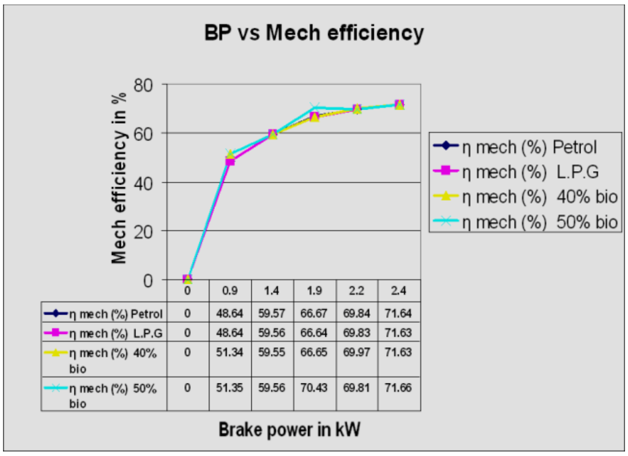


Fig. 5 Mechanical Efficiency Graph.

It is observed from the graphthat mechanical efficiency is minimum atlow bp and it increasing with increaseofbrake power for all fuels. For a blend of50%, the mechanical efficiency is highwith compare to the other fuels at all brakepower values. The blend of 50 % of biogasthe performance of the engine is good.

III. Result And Discussion

The conversion method that was shown in this paper has been successful to run the electric generator that was previously fuelled by gasoline to be converted by using biogas. The engine run stable and can produce electricity. The maximum RPM (revolution per minutes) that can be obtained by using 100% biogas was found about 1500 rpm. This makes sense since the energy of the biogas is lower than the gasoline one that is about 6.0-6.5 kWm-3. When The LPG is added to about 5% (95% biogas) in to the mixture, the engine speed was found about 1600 rpm. The engine speed is still not increased significantly with addition 10% LPG which the speed was about 1750 rpm. The significant increase in engine speed was found with addition 15% LPG that yielded about 2600 rpm of engine speed. Finally the engine speed reached its maximum value about 3600 rpm by adding about 20% LPG. The maximum value of the engine speed by using gasoline fuel is 3600 rpm. Therefore to obtained maximum engine speed by using technique developed in this research, the biogas need to be added about 20% with LPG in order to reach the same maximum speed by using gasoline as presented in Fig.3. By using desulfurizer the biogas can be upgraded to zero content of H_2S impurities that lead to avoid increasing acidity of the lubricant therefore the corrosion in the combustion chamber can be avoided. Previously the existence of H_2S in the biogas was overcome by increased frequency of engine oil change, which will increase the operating cost. Other urgent thing that make H_2S should be eliminated due to H_2S is a Toxic gas. By reducing the water content in the biogas up to zero level affect in easy starting of the engine.

The use of the bag gas holder of the biogas was useful during compressing of the biogas in to the gas container because this is make easy to be observed whether biogas available or not during compression. It should be noted here that biogas, containing mainly methane, could not be stored easily, as it does not liquefy under pressure at ambient temperature (critical temperature and pressure required are -82.^{o}C and 47.5 bars). Compressing the biogas reduces the storage requirements, concentrates energy content and increases pressure to the level required overcoming resistance to gas flow[1].

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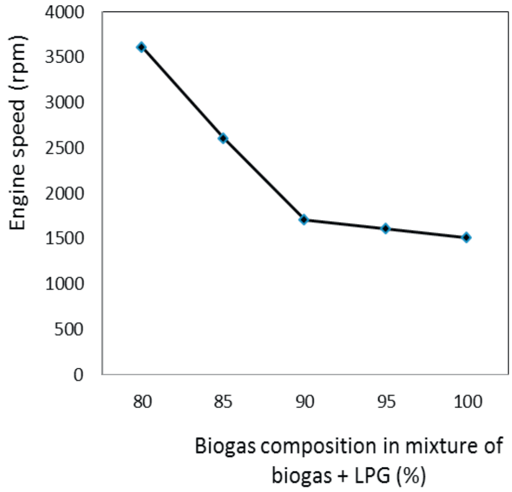
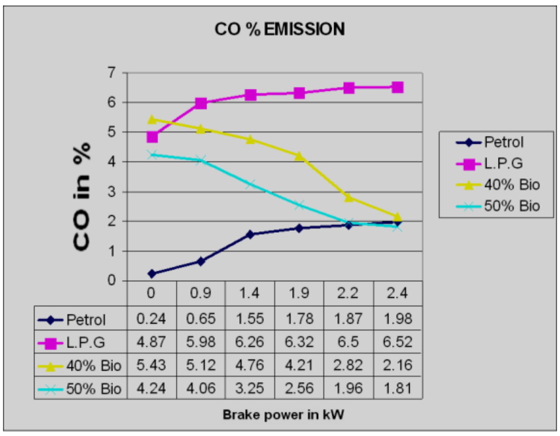


Fig. 6. The effect of composition of biogas-LPG mixture on the speed of the engine [1]

It is good to suggest here a useful method to reduce the CO_2 impurities in the biogas. A method that is introduced by Mohseni et al. To increase the biogas yield, the separated carbon dioxide could be used as a component to produce additional methane through the well-known Sabatier reaction. In such process the carbon could act as hydrogen carrier of hydrogen originating from water electrolysis driven by renewable sources.

1. Emission Characteristics:
Carbon Monoxide



	0	0.9	1.4	1.9	2.2	2.4
Petrol	0.24	0.65	1.55	1.78	1.87	1.98
L.P.G	4.87	5.98	6.26	6.32	6.5	6.52
40% Bio	5.43	5.12	4.76	4.21	2.82	2.16
50% Bio	4.24	4.06	3.25	2.56	1.96	1.81

Fig. 7 CO Emissions.

The CO values with break power fordifferent fuels are shown in above figure -4 , it is observed that the CO decreaseswith increasing load for all the blends. Fordifferent blends of biogas, CO is reducing.It can be observed that blending 50% ofbiogas with L.P.G results high reduction inCO emissions when compared to that ofpetrol, L.P.G, 40% blending.

Nitrogen Oxides:

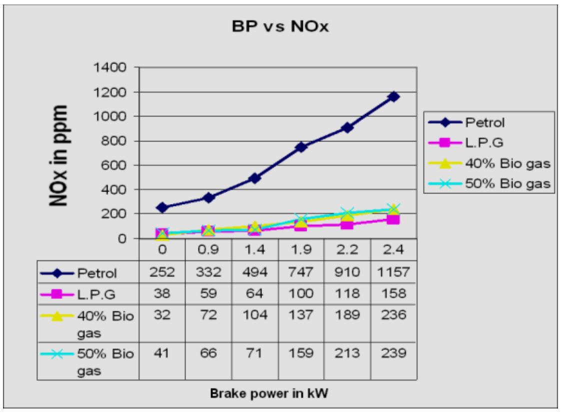


Fig. 8 Nitrogen Oxide Graph (emission).

The comparison of NOx emissionscompared with brake power for petrol,L.P.G and the blend with biogas areshown in Fig 5, it is observed that NOxincreases with increasing load for all fuels.If the percentage of Biogas increases, NOxwill be increased because of biogas containsCO2. From the figure it is observed lathe emission value of NOx are minimumfor the biogas blend with compared to thepetrol. Because it is a low calorific valuefuel and it is a homogenous mixture.That's why, there is no formation of NOx.

IV. Conclusion

The conversion from gasoline to biogas fuelled engine can be achieved by desulfurizing of the biogas at the first step continued with dehumidification and put the gas in to the bag of gas holder. The biogas then should be compressed into the gas container for easy mixing process with oxygen from the air. The carburetion component was replaced and only mixer part of the fuel is used. Initially in the process, the biogas is let to flow in maximum flow rate and reduce the rate until engine start running. The process is followed by adjusting the air flow in to the mixer until the engine run stably. To increase the speed of the engine, the liquefied petroleum gas (LPG) is added to the mixture up to 80% of biogas and 20% LPG.

The petroleum fuel with itscombustion products, pollute the air togreat extent. In this case the intensity ofpollution problem will be less because ofblending this eco-friendly fuel biogas.Thus biogas may be the promising fuel forthe future.

References

[1]. WayanSurata, TjokordaGdeTirtaNindhiab, I KetutAdiAtmikac, Dewa NgakanKetut Putra Negarad, and I WayanEkaPermanaPutrae, Simple Conversion Method from Gasoline to Biogas Fuelled Small Engine to Powered Electric Generator Energy Procedia 52 (2014) 626 – 632.

[2]. Rakopoulos, C.D. and Michos C.N. Generation of Combustion Irreversibilities in a Spark ignition Engine under Biogas–Hydrogen Mixtures Fueling.Int J Hydrogen Energy 2009; 34:4422-37.

[3]. Chien,Y. K., Sheng. C., Tzu, T.H., Le, D., Ling,K. H., and Chih,S. L. Ability of a Mutant Strain of the Microalga Chlorellasp. to Capture Carbon Dioxide for Biogas Upgrading. Applied Energy 2012; 93:176-83.

[4]. Tippayawong, N., and Thanompongchart, P. Biogas Quality Upgrade by Simultaneous Removal of CO_2 and H_2S in a Packed Column Reactor.Energy2010; 35:4531-5.