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Performance and Emission Characteristics of SI Engine using LPG –Biogas Blend: A Review

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Abstract—*IC engines are considered as major contributors to the deterioration of the environment, therefore there is an increasing demand to go for alternative fuels for both SI and CI engine so as to maintain the ecological balance as well as reduce dependency on petroleum from socio-economic aspects. The gaseous fuel such as LPG has been widely used throughout the world in SI engines as it impacts greenhouse emissions less than any other fossil fuel. In the study carried out during literature survey it was found that the concentration level of CO, HC and CO_2 were on the lower side for LPG as compared to gasoline for the same power output. Similarly Biogas which is derived from organic wastes is also considered as good alternative to petroleum fuels. It can be used in spark ignition (SI) engines, because of its better mixing ability with air and clean burning nature. This fuel offers low cost and low emissions than any other secondary fuels. It can be a supplemented to liquefied petroleum gas (LPG), if it is used in compressed form in cylinders.This paper presents a review about the previous research efforts into SI engine using LPG and biogas as an alternative fuel for the purpose of improving emission characteristics and engine performance. Also deriving an inspiration from the work conducted previously a project involving the use of these alternate fuels has been proposed. The proposed work includes utilisation of LPG fuel blended with Biogas in various proportions. Firstly engine will be tested with gasoline at normal working conditions later same engine will tested out with a blend of LPG and Biogas (25%, 50%, and 75%). The suggested work will be carried out on a commercial engine so as to find whether we can implement the changes on on-going engine and improve its performance.*

1. INTRODUCTION

Petrol is a fossil fuel made from crude oil. The supply of petrol is limited. India is mainly dependent on Arab countries for their fuel supplies. The specter of economy ruin due to depleted oil reserves has changed the interest of scientist and research work towards alternative fuels for motor vehicle. While alcohol is used as a fuel, it's feasibility as motor fuel depends on the successful cultivation and processing of sugarcane. Gaseous hydrocarbons seem to be the best immediate option presently available. These are mainly compressed natural gas (CNG) & liquefied petroleum gas (LPG).

LPG is obtained from the process is the process of natural gas and crude oil extraction and as by-product of oil refining. Its primary composition is a mixture of propane and butane. It has higher octane number (105) than petrol (91-97).The use of LPG in internal combustion engines yielded higher thermal efficiency and better fuel economy compared to unleaded gasoline. This is due to mainly the higher octane rating which permits greater engine compression ratio without the occurrence of knock. LPG also has higher heating value compared to other fuels and can be liquefied in a low pressure range of 0.7 to 0.8mpa at atmospheric pressure. Gaseous fuels such as liquefied petroleum gas (LPG) and liquefied natural gas (LNG) have been widely used in commercial vehicles, and promising results were obtained in terms of fuel economy and exhaust emissions. LPG gas as a low carbon and high octane number fuel produces lower carbon dioxide (CO_2) emission as compared to gasoline. The use of LPG as an alternate fuel for road vehicles has been studied extensively in recent years i.e., approximately 4 million vehicles are operating on LPG worldwide. Most of these were mainly light, medium and heavy-duty trucks originally operated on gasoline and later converted to LPG using approved and certified conversion kits. Many investigations have reported favorable results from emission perspectives when LPG is used as an alternative fuel in spark ignition engines. Emissions from LPG vehicles are significantly lower than conventionally fuelled vehicles. LPG operated vehicle reported hydrocarbon (HC) emissions as 40% lower, carbon monoxide (CO) as 60% lower and carbon dioxide (CO_2) as substantially reduced. In addition, since LPG has lower carbon content than gasoline, it virtually produceszero emissions of particulate matter and lower amount of NO_x emission as well.

Also India is largest cattle breeding country; there is abundance of raw material for producing biogas. Also municipal wastes & kitchen wastes can be used for this purpose. The use of methane (CH_4) separated from biogas as a fuel will substantially reduce harmful engine emission and will help to keep the environment clean. Biogas consists of approximately 50-70 % methane. It is economical and slurry can be used as organic manure. The main advantage of biogas

is that it can be produced in rural areas from readily available materials. Biogas consist mainly methane and carbon dioxide is low but its knock resistance is high.

2. SIGNIFICANCE OF BIOGAS

- With production based upon wastecooking products, agricultural waste products and from cow dungs which are produce the biogas and like goobergas, increased consumption of biogascreates economic development andadditional markets for agriculturalproducts.
- In-turn, this creates new jobs in ruralcommunities and keeps moneycirculating throughout the domesticeconomy. Producing a percentage ofour fuel at home increases our nation'senergy independence.
- Using biogas in place of petroldecreases hydro carbon emissions(greenhouse gases) by nearly 65%.
- The inherent lubricity of Biogasincreases the performance of aninternal combustion engine. Biogas isa "premium" natural gas fuel thatcleans fuel system, improvesengine lubrication and reducesparticulate emissions, all of whichhelp to extend the life of engineequipment.

3. COMPOSITION AND PROPERTIES OF BIOGAS

Biogas is a mixture of gases that is composed chiefly of:

- Methane (CH_4): 40-70 vol.%
- Carbon dioxide (CO_2): 30-60 vol.%
- Other gases: 1-5 vol.% including
- Hydrogen (H_2): 0-1 vol.%
- Hydrogen sulphide (H_2S): 0-3 vol.%

3.1 Feed stock (raw material) of biogas

- **Agricultural Feedstock**
  - Animal manure
  - Energy crops
  - Algal biomass
  - Crop residues
- **Community-Based Feedstock**
  - Sewage sludge
  - Grass clippings/garden waste
  - Food remains
  - Institutional wastes etc.
- **Industrial Feedstock**
  - Food/beverage processing
  - Dairy
  - Starch industry
  - Sugar industry
  - Pharmaceutical industry
  - Cosmetic industry
  - Biochemical industry
  - Pulp and paper

4. BIOGAS APPLICATIONS

1. For cooking and heating.
2. As an illuminatant for domestic and street lighting.
3. For running tube well and water pump.
4. With minor modifications, conventional internalcombustion engines, diesel and petrol engine both run on biogas.

5. PROPERTIES OF LPG

LPG has been and continued to be the most widely used alternative burning fuel. Listed below are somecharacteristics of LPG

1. LPG is a colourless gas regardless of its state. Chilled water vapour condensed from the surrounding air will appearas white cloud around the LPG leakage point.
2. LPG is odourless or has no smell. Stench agent such as Mercaptan is added before delivery to detect leakage.Mercaptan additive has an unpleasant and foul smelling so that leak can be easily detected.
3. LPG is chemically reactive and will cause natural rubber and some plastics to deteriorate. Hence, it is advisable touse equipment specifically designed for LPG.
4. LPG is highly volatile and flammable. Thus, it must be stored in a high ventilation rate area and kept away fromany sources of ignition.
5. LPG vapour is denser than air. Propane is about one and a half times as heavy as air. Any leakage of LPG will sinkto the ground and accumulate in low lying areas due to its high density property. Hence, LPG is not advisable tobe stored in basements. Although LPG is non-toxic, it has an anaesthetic effect when present in highconcentrations.

6. FEATURES OF LPG FOR ENGINE APPLICATION

1. The cost of LPG is less than that of gasoline and available in abundance.
2. LPG has a comparable performance if compared to the conventional fuels with lower pollutant emission.
3. LPG is friendly to the environment. It produces less pollutant to the atmosphere with virtually no particulatematters (PM), low level of carbon monoxide (CO), hydrocarbons (HC), and oxides of nitrogen (NOx). LPG emitsless greenhouse gases (GHG) compared to any other fossil fuel when measured through the total fuel cycle.
4. LPG is used in commercial and domestic heating; it is portable because it is stored in steel tanks which are easilytransferred to other places.
5. LPG has a very good safety record over the years. The conversion kits readily available in the market enable LPGto continue being a widely used road fuel
6. Researchers have shown that engine maintenance is reduced significantly because LPG does not wash thelubricant oil from the cylinder walls or dilute the oil.

Hence, engines using LPG as the burning fuel always enjoya longer service life and reduced maintenance costs.

7. LIMITATION

Although LPG has a great deal of advantages,it has some limitations too as listed below

1. LPG is a non-renewable fossil fuel. If we use LPG faster than the rate of its generation, it will begin to deplete.
2. LPG is denser than air, and may pose a risk when leakage occurs as it will accumulate in low-lying areas.
3. A bulky storage tank is needed to store LPG. Hence, larger boot area is required to place the storage tank in place. The heavier storage tank also reduces the storage capacity and may cause inconvenience.
4. It was revealed that there exist a number of countries with underdeveloped technologies for LPG distributionsystem and therefore, limits its usage. LPG is only used in residential homes as heating and cooking gas.
5. The contents of propane in LPG are different for most countries. For instance, LPG contains more than 90 %propane in UK, whereas in Italy the level can be as low as 20% and 70% in India. This fluctuation proves to be abarrier to standardization of LPG vehicles around Europe and the rest of the world.

8. LITERATURE REVIEW

Venkata Ramesh Mamilla, V.Gopinath, C.V.SubbaRao, Dr.G.LakshmiNarayanaRao (2011) [1]has worked on the performance and emission characteristics of 4 stroke petrol engine fuelled with biogas / LPG blends. From this experiment it was clear that at 50% blending of biogas the engine performance is found to be very appreciable. At this 50% blending trial particularly at full load the specific fuel consumption and brake thermal efficiency are high when compare to the petrol, LPG and the mechanical efficiency is high for the 50% blending with compared to the Petrol, L.P.G, and 40% Blending. And, also the emission values of CO, HC and NOx wereminimum for the biogas when compared to the petrol.

K.A. Subramanian, Vinaya C. Mathad , V.K. Vijay , P.M.V.Subbarao(2013) [2] has work on the topic of Comparativeevaluation of emission and fuel economy of an automotivespark ignition vehicle fuelled with methane enriched biogasand CNG using chassis dynamometer. The emissions such asCO, HC and Nox were marginally higher with the enrichedbiogas than base CNG. But, the experimental results indicatethat the vehicle's emission with the enriched biogas fuelmeets to the BS IV Emission Norms. There is no significantchange in fuel economy of the vehicle fuelled with theenriched biogas (24.11 km/kg) as compared to base CNG(24.38 km/kg. As themethane enriched biogas gives similar performance likefossil CNG, the enriched biogas could be used as an auto fuelfor spark ignition vehicles.

K F Mustafa, H W Gitano-Briggs(2008) [3]Presents an experimental investigation of a Liquefied Petroleum Gas (LPG) fuelled four-stroke spark ignition engine. The engine used in the study was originally a four-stroke spark ignition gasoline engine and minor modifications were carried out to permit the experiments to run on LPG fuel. The result shows that the level of carbon dioxide (CO_2) peaked at around relative air-fuel ratio of 1.0 and carbon monoxide (CO) exhibits a sharp decreased as the relative air-fuel ratio increases. Unburned hydrocarbons (UHC) also shows marked reduction as the relative air-fuel ratio exceeds stoichiometric and nitrogen oxides (NOx) exhibits an increasing trend as the relative air-fuel ratio increases.

Mr. Sanjay D Bisen and Mr. Yogesh R.*Suple (2013)*[4] showed the effect of direction injection (DI) of LPG in the chamber of single cylinder four stroke engine with the help of a nozzle. Experiments were carried out at 400 rpm and at variable loads and the final result obtained showed the decrease in BSFC with increase in brake power for LPG as compared to gasoline. When using LPG the brake thermal efficiency values slightly higher than using gasoline and the value of volumetric efficiency for LPG was lower than that of gasoline. Using LPG the mass of fuel consumption values is lower than the using gasoline fuel and also burning rate of fuel is increased, and thus, the combustion duration is decreased. This resulted in the rise of cylinder pressures and temperatures for LPG when compared to gasoline.

DebabrataBarik, SudhirSah, S. Murugan (2012)[5]Different techniques for CO_2, H_2S scrubbing were discussed, among which water scrubbing is a simple continuous and cost effective method. This gives 87.6% and 100% pure methane with biogas flow rates of $2m^3$/hr. and $1.8m^3$/hr. respectively. Also their Study shows that Monsanto and acetate cellulose membranes give best separation to CO2, O_2 and H_2S at pressure and temperature of 5.5 bars and 25^oC. Biogas in SI operation, the thermal efficiency was improved from 26.2% to 30.4%, when there was 21% reduction of CO_2in biogas.

Shankar K. S, Mohanan P (2011) [6] investigated the effect of variation in ignition timing on the performance of a four cylinder multipoint port fuel injection gasoline engine which is retrofitted to run with LPG injection. Experiments were conducted at varying engine speed at 5° BTDC and then advancing the timing to 6° BTDC and then retarding the ignition timing to 4° and 3° BTDC. It was found that at 5° BTDC the brake thermal efficiency of LPG is less than gasoline at lower engine speeds but at higher engine speed after 3500 rpm LPG shows higher thermal efficiency than gasoline. Since the ignition temperature is high for LPG therefore combustion duration is more and this decreases average burning rate. Engine consumes more fuel and thus decreases in efficiency observed. But at higher engine speeds, the flame propagation speed of LPG is increased which lowers the time duration for each cycle and thus demands more rate of combustion and hence efficiency increases. The CO

emissions reduced from an average value of 5% to 1.5% with the use of LPG. It was found that HC emission reduced drastically for LPG at all the throttle positions while No_x emission were found to be increased for LPG and were almost double at 4500 rpm. By advancing the ignition timing to 6° BTDC, the combustion duration increases which enhances the power output at lower engine speeds and therefore efficiency is high at lower engine speeds at 6° BTDC.

9. CONCLUSION

From above literature it can be concluded that LPG is suitable alternative for SI engine. But the performance andemission characteristic of LPG fuelled engine was studied at lower compression ratio. And it was observed that engineoutput decreases as its known, LPG has a high octane number. Thus, it may lead to operating with higher compression ratios, and consequently, the engine efficiency and fuel economy would be better than those which were determined here. Also in case of Biogas, Biogas after removal of $CO_2$and H_2S by use of scrubbing method, is enriched in methane (CH_4) and becomes equivalent to natural gas but limitation is production rate is very low. After studying of research paper, we can say that biogas is a most important renewable source of energy. Biogas is a cheaply available in India. By using of biogas in automobile/vehicle engine, we can reduce the exhaust emissions to some level.

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