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THEORITICAL ANALYSIS ON BIOGAS ENGINE TECHNOLOGY

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ABSTRACT

Bio fuels derived from biomass are considered as good alternative to petroleum fuels. Biogas can be used in internal combustion (IC) engines, because of its better mixing ability with air and clean burning nature. It can be a supplemented to liquefied petroleum gas (LPG) and compressed natural gas (CNG), if it is used in compressed form in cylinders. Lower hydrocarbon (HC), smoke and particulates emission has been reported in diesel engines operating on biogas diesel dual fuel mode. The paper reviews on effects of biogas contents on performance of IC engine, process of removal of undesirable contents, biogas in IC engine applications and exhaust emission to avoid any additional greenhouse gas.

Keywords : Biogas, IC engine, combustion.

I. INTRODUCTION.

The world faces twin problems of energy crisis and environmental degradation. Utilization of natural gas in I.C. engine is an option to overcome some problems. The natural gas fuelled vehicle gives higher thermal efficiency and lesser emissions as compared to fossil fuelled vehicles.

It has been witnessed that number of natural gas fuelled vehicle increased from 1 million to 11 million during past decade (2000–2010)[13,14]. The world total reserve to production (per year) ratio of natural gas has also decreased and in as usual business scenario, the existing reserves would vanish within 58.6 years. The gap between demand and production of natural gas increases steeply resulting to unsustainable energy development in natural gas consumed sectors such as automobile, power generation, industrial fuel, domestic fuel, fertilizer industry, petrochemicals and others. Even though various renewable energy sources are available to overcome this energy crisis, biogas is an option as it can readily be injected into natural gas grid and utilized in energy industries including road transport sector. Even utilizing biogas in the engines avoids any additional greenhouse gas emission.

Biogas is produced by anaerobic digestion of various organic substances such as kitchen wastes, agricultural wastes, municipal solid wastes and sewage, cow dung etc., which offers low cost and low emissions than any other secondary fuels. India is largest cattle breeding country; there is abundance of raw material for producing biogas.

The use of methane separated from biogas as a fuel will substantially reduce harmful engine emission and will help to keep the environment clean.

Biogas is composed mostly of CH_4 (50–70%) and CO_2 (25–50%), with low fractions of H_2 (1–5%), N_2 (0.3–3%), and hydrogen sulphide (H_2S) traces.

The enriched biogas would give high beneficial result to rural mass transport sector for improving rural economy as rural villages have abundant availability of biogas resources such as cattle dung, kitchen wastes, agricultural wastes, municipal solid wastes and sewage etc.

II. LITERATURE SURVEY :

Jiang[6]Evaluate the engine performance by Characteristic curve using a mixture of diesel oil and low-pressure & high-pressure biogas. The knocking produced by connecting high-pressure biogas directly into the engine is stronger than that produced by connecting low-pressure biogas.

There was no corrosion of the engine throughout all the biogas tests carried out by us. The life of the engine will not be shortened by the use of biogas, provided the engine is properly maintained. The compression of biogas is possible and the application of biogas as a fuel for dual- fuel diesel-biogas engines is feasible and economical.

Henham and M.K.Makkar[15]Examines engine performance using simulated Biogas. Total 60% gas oil substitution is possible by gas mixture without knock. Overall efficiency falls with gas mixture substitution and adding CO_2 at higher speed There is a more rapid pressure rise on combustion with dual fuel operation.

Crookes[7] An experimental examination for performance and emissions from compression-ignition engines, running on a variety of bio-fuels.For bio-gas, containing carbon dioxide, emissions of oxides of nitrogen were reduced relative to natural gas, while unburnt hydrocarbons were increased. Brake power and specific fuel consumption changed little and carbon monoxide was predominantly affected by air: fuel ratio.

S.Nathan, J.M. Mallikarjuna & A Ramesh [16] Investigate the potential of the HCCI engine by varying the charge temperature of biogas and its various proportions was studied. This work has shown that biogas can be effectively used in the HCCI mode with manifold injected diesel and charge temperature being employed for controlling combustion. The high self ignition temperature of methane helps delay the combustion process to favourable crank angles.(iii)Efficiencies close to diesel operation along with extremely low levels of NO and smoke were attained.

III. BIOGAS ENGINE TECHNOLOGY :

3.1 Effects of biogas contents on performance of IC engine.

High hydrogen sulfide in biogas is the common problem for IC engines. During combustion, H_2S will react and forms SO_2 and H_2SO_4 then reacts with H_2O to form H_2SO_3. SO_2 can also react with O_2 to form SO_2 and then with H_2O to H_2SO_4. These acids lead to engine parts corrosion. Engine wear is reported due to acid formation.

The acidic exhaust gas can block heat exchanger with deposits from corrosion and then cause high exhaust back pressure Excessive valve and valve seat wear is reported when oil analysis showed increased amount of silica particles. High CO2 content reduces the power output, making it uneconomical as a transport fuel. It is possible to remove the CO2 by washing the gas with water. There is high residual moisture which can cause starting problems.

3.2 Process of removal of undesirable content in Biogas for I.C.Engines.

3.2.1. Removal of CO_2

CO_2 is high corrosive when wet and it has no combustion value so its removal is must to improve the biogas quality. The processes to remove CO_2 are as follows.

a) Caustic solution,

NAOH(40%)+CO2 = NAHCO3

b) Refined process,

K2CO3(30%)+CO2 = 2KCO3

CO_2 removal from biogas can be done by using chemical solvents like mono-ethanolamine (MEA), di- ethanolamine and tri- ethanolamine or aqueous solution of alkaline salts, i.e. sodium, calcium hydroxide and potassium.

Biogas bubbled through 10% aqueous solution of MEA can reduce the CO_2 content from 40 to 0.5-1.0% by volume. Chemical agents like NaOH, $Ca(OH)_2$, and KOH can be used for CO_2 scrubbing from biogas. In alkaline solution the CO_2 absorption is assisted by agitation. NaOH solution having a rapid CO_2 absorption of 2.5-3.0% and the rate of absorption is affected by the concentration of solution.

3.2.2. Removal of H_2S.

In physical separation pressurized water is used as absorbent, as both CO_2 and H_2S are water soluble agents. The water scrubbing method is used for biogas up gradation. The rate of CO_2 and H_2S absorption depends upon the factors such as, gas flow pressure, composition of biogas, water flow rates, and purity of water and dimension of scrubbing tower.

3.3 Biogas in I.C.Engine applications.

Biogas can be used in both heavy duty and light duty vehicles. Light duty vehicles can normally run on biogas without any modifications whereas, heavy duty vehicles without closed loop control may have to be adjusted, if they run on biogas. Biogas provides a clean fuel for both SI (petrol) and CI (diesel) engines. Diesel engines require combination of biogas and diesel, while petrol engines run fully on biogas. Use of biogas as an engine fuel offers several advantages. Being a clean fuel biogas causes clean combustion and recesses contamination of engine oil.

Biogas cannot be directly used in automobiles as it contains some other gases like CO_2, H_2S and water vapour. For use of biogas as a vehicle fuel, it is first upgraded by removing impurities like CO_2, H_2S and water vapour. After removal of impurities it is compressed in a three or four stage compressor up to a pressure of 20 MPa and stored in a gas cascade, which helps to facilitate quick refueling of cylinders. If the biogas is not compressed than the volume of gas contained in the cylinder will be less hence the engine will run for a short duration of time.

3.3.1 Biogas in Diesel Engine applications.

Biogas generally has a high self-ignition temperature hence; it cannot be directly used in a CI engine. So it is useful in dual fuel engines. The dual fuel engine is a modified diesel engine in which usually a gaseous fuel called the primary fuel is inducted with air into the engine cylinder. This fuel and air mixture does not auto ignite due to high octane number. A small amount of diesel, usually called pilot fuel is injected for promoting combustion. The primary fuel in dual fuelling system is homogeneously mixed with air that leads to very low level of smoke. Dual fuel engine can use a wide variety of primary and pilot fuels. The pilot fuels are generally of high cetane fuel. The performance of engine depends on the amount of biogas and the pilot fuel used. Measures like addition of hydrogen, LPG, removal of CO_2 etc. have shown significant improvements in the performance of biogas dual fuel engines.

3.4 Exhaust emission.

The exhaust emission contains three specific substances which contribute the air pollution, hydrocarbon, carbon monoxide &oxides of nitrogen. Hydrocarbons are the unburned fuel vapour coming out with the exhaust due to incomplete combustion. Hydrocarbon also occurring in crankcase by fuel evaporation. The emission of hydrocarbon is closely related to many design &operating factors like induction system, combustion chamber design, air fuel ratio, speed, load. Lean mixture lower hydrocarbon emission. Carbon monoxide occurs only in engine exhaust. It is the product of incomplete combustion due to insufficient amount of air in air- fuel mixture. Some amount of CO is always present in the exhaust even at lean mixture. When the throttle is closed to reduce air supply at the time of starting the vehicle, maximum amount of CO is produced. Oxides of nitrogen are the combination of nitric oxide & nitrogen oxide &availability of oxygen are the two main reasons for the formation of oxides of nitrogen. With biogas, co emission levels are low than that of gasoline.

IV. CONCLUSION :

The study concludes the effects of biogas contents on performance of biogas fueled IC engine. Different techniques for removal of undesirable content like CO2 and H2S from biogas and its effects on I.C.Engines. Attention is also focused biogas as alternate fuel in Diesel engine and exhaust emission to reduce green house effects.

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