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A REVIEW PAPER ON PERFORMANCE EVALUATION OF BIOGAS ENGINE

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ABSTRACT

Biogas is a fuel and an attractive source of energy for rural areas. It is also used in Internal Combustion (IC) engine and used in both petrol as well as diesel engine. The reduction in concentration of CO2 i.e. increasing methane content in the biogas will improve performance and reduces emissions of hydrocarbons and leads to higher faster combustion for the engine. Piston geometry also affects the performance of the engine because flat piston produces large torque, more power output and low hydrocarbon emission. The paper is focused on performance of the IC engine on biogas as a fuel. The effect of CO2 concentration on performance of biogas engine also engine performance on duel fuel mode, effect of compression ratio and significance of compression ratio on performance of the biogas engine.

KEYWORDS : Biogas, HCCI, TDC.

I. INTRODUCTION :

The gradual reduction of the petroleum reserves such as petrol diesel etc and the increase of pollutant emissions have demanded the search and development of alternative and renewable energy sources which can help to reduce the current oil dependency. In the field of ICE, gaseous fuels have considered as good alternatives to traditional petroleum derived fuels, such as diesel and gasoline.

Conventional hydrocarbon fuels used in I C Engines lead to pollutants like Hydrocarbons (HC), Carbon dioxide (CO_2),Carbon monoxide (CO), nitrogen oxides (NO_x), particulates and sulfur oxides (SO_x).

Gas is clearly the fossil fuel of least environmental impact. It produces virtually no SO_x and relatively little NO_x, which is the main constituents of acid rain, and substantially less CO_2, than most oil products and coal.

Gaseous fuels are attractive because of their wide ignition limits and capability to form homogeneous mixtures. Moreover gaseous fuels have high hydrogen to carbon ratio. Thus very low emissions are possible when they are used in IC engines.

Natural gas and LPG are the readily available petroleum-based fuels, while hydrogen, biogas and producer gas can be obtained from renewable sources.

Biogas is an attractive source of energy for rural areas and can be produced from cow dung, animal wastes and also from plant matter such as leaves and water hyacinth-all of which are renewable and available in the countryside.

II. LITRATURE SURVEY :

S.Swami, Mallikarjuna & Ramesh [1] investigate engine operation on biogas–diesel HCCI mode. Biogas was used in a HCCI engine with charge temperature and amount of diesel injected into the intake manifold being used to control combustion. The presence of CO in biogas suppresses the high heat release rates encountered with neat diesel fuelling in HCCI engines. Use of biogas leads to a drop in thermal efficiency in both SI and CI engines but in HCCI mode thermal efficiency is close to diesel engine.

HC levels were very high and were lowered when the charge temperature was raised.

Henham[2] at al, have experimented on dual fuel operation with diesel and biogas with varying quality of gas as 22%, 37%, 45% and 58%.They have performed experiment on two-cylinder, four-stroke, water-cooled, indirect injection Lister Petter LPWS2 diesel engine. They found that it is possible to substitute gasoil by gas mixture up to about 60% without knocking. Increasing gas substitution will lower down overall efficiency. Exhaust temperature and CO are mostly affected by gas substitution.

E. Porpatham[3] at al, have performed experiment on influence of reduction in the concentration of CO_2 in biogas on performance, emissions and combustion in spark ignition engines. Different levels of biogas concentrations such as 41% to 30% and 20% were used in single cylinder agricultural diesel engine with a rated output of 4.4 kW at 1500 rpm which was converted in SI mode. They found that reduced concentration of CO_2 in the biogas will improves performance and reduces emissions of hydrocarbons and leads to higher faster combustion and also higher power outputs at a given equivalence ratio. The thermal efficiency of engine was 26.2% with normal biogas which was improved up to 27.1% and 30.4% with CO_2 concentrations of 30% and 20%, respectively.

Seung Hyun Yoon [4] at al, have experimented on influence of dual-fuel combustion characteristics on the exhaust emissions and combustion performance in a diesel engine fueled with biogas–biodiesel dual fuel. They concluded that when Biogas–biodiesel used in CI engine than they showed remarkable performance in reduction of soot emissions due to the absence of aromatics and low sulfur content. The concentrations of hydrocarbon and Carbon monoxide emissions were considerably higher for the dual-fuel mode with both pilot fuels than those for the single-fuel mode under all test conditions.

R.Chandra and at al [5], have performed experiment on evaluation of a constant speed IC engine on CNG, methane enriched biogas and biogas. They used a 5.9 kW stationary diesel engine which was converted into spark ignition mode with 12.65 compression ratio with variation in ignition advance of TDC such as 30˚, 35˚ and 40˚.It is fond that the maximum brake power produced at ignition advance of 35˚ TDC for all the tested fuels. There were almost similar engine performance as compared to compressed natural gas in terms of brake power output, specific gas consumption and thermal efficiency with methane enriched biogas.

R.J. Crookes[6] have experimented comparative bio-fuel performance in internal combustion engines.

In an experiment, performance and emissions from spark and compression-ignition engines, running on a variety of bio-fuels, including simulated bio-gas and commercial seed oil. The test on engine on variable compression ratio. In the result 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. Equivalent effects were demonstrated with nitrogen replacing carbon dioxide in the simulated.

Omid Razbani, Nima Mirzamohammad, Mohsen Assadi[7] Literature review and road map for using biogas in internal combustion engines. Investigate combustion characteristics of biogas in reciprocating engines, challenges for biogas as a fuel are lower flame speed (compared to natural gas) and biogas impurities. In solutions advancing spark timing, increasing compression ratio, changing the bearing and piston materials and pre-chamber ignition systems are presented.

Biogas having carbon dioxide and has a high heating value and it even increases with temperature, that means in high combustion temperatures lots of heat is absorbed by CO2 and thus reducing the flame temperature significantly.

In the survey they studied significance of compression ratio on power output at various equivalent ratios & importance of advancement of the spark timing for enhancing the engine power output.

R.F. Huang [8] at al, have evaluated in-cylinder flow structures and turbulence using flat-crown and slightly concave-crown pistons with the help of particle image velocimeter. They used a four-stroke, four-valve, dual-cylinder engine with V-90˚ arrangement for experiments. From experiments they concluded that the flat-crown piston generates higher tumble ratio and turbulence intensity than the slightly concave-crown piston because of higher tumble ratio and turbulence generated by the flat-crown piston in the offset planes during the compression stroke. The engine having the flat-crown piston presents larger torque and power outputs and lower hydrocarbon emission compared with the slightly concave-crown piston.

Phan & Wattanavichien [9] investigated biogas premixed charge diesel dual fuelled engine.

Biogas–diesel dual fuelling of this engine revealed almost no deterioration in engine performance but lower energy conversion efficiency which was offset by the reduced fuel cost of biogas over diesel. The long term use of this engine with biogas–diesel dual fuelling is feasible with some considerations.

Rajesh C. Iyer[10] investigated on the influence of ignition voltage, higher compression ratio and piston crown geometry on the performance of compressed natural gas engines. They used a single cylinder 100cc category, 4-S S.I engine operated on CNG. There was a stationary test rig setup in which 3 piston geometries were investigated for performance and emissions and compared between gasoline and CNG. They concluded that the increase in compression ratio for a piston from 6.2:1 to 7.1:1 as against the base configuration 8.2:1 has showed better results. There was an increase in power by 30 % when tested at the gear shaft end compared to gasoline.CO reduced by 4 times and a 15 % reduction in CO_2 is found in comparison to the other pistons. There was 10 % improvement in power in CNG compared to gasoline by increasing the ignition voltage in CNG.

III. CONCLUSON :

Biogas was used in a HCCI engine with charge temperature and amount of diesel injected into the intake manifold being used to control combustion. [1]

- It is possible to substitute gasoil by gas mixture up to about 60% without knocking. Exhaust temperature and CO are mostly affected by gas substitution[2].
- The reduction in concentration of CO_2 in the biogas will improves performance and reduces emissions of hydrocarbons and leads to higher faster combustion and also higher power outputs at a given equivalence ratio[3].
- Biogas–biodiesel used in CI engine showed remarkable performance in reduction of soot emissions due to the absence of aromatics and low sulfur content[4].
- With increase in compression ratio, the brake thermal efficiency increases. The significant reduction in the ignition delay and higher heat release rate with increase in compression ratio[5].
- Bio-gas, containing carbon dioxide, emissions of oxides of nitrogen was 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. Equivalent effects were demonstrated with nitrogen replacing carbon dioxide in the simulated.[6]
- The engine having the flat-crown piston presents larger torque and power outputs and lower hydrocarbon emission compared with the slightly concave-crown piston[8].
- Biogas–diesel dual fuelling of this engine revealed almost no deterioration in engine performance but lower energy conversion efficiency which was offset by the reduced fuel cost of biogas over diesel. The long term use of this engine with biogas–diesel dual fuelling is feasible with some considerations.
- Performance of an engine can be improved by identifying suitable piston crown shape and also increasing the compression ratio by machining the surface of piston crown. Power output can be improved by augmenting the ignition voltage by increasing winding of ignition coil[10].

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