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EXPERIMENTAL STUDY ON UTILIZATION OF BIOGAS IN IC ENGINE

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ABSTRACT

In recent years man's dependency on energy has increased rapidly mainly because of the increase in the living standards and use of advance technologies, So that non-renewable fossil fuel reserves being exhausted and there are issues related to their GHG (Green House Gas) emissions such as, carbon monoxide (CO), carbon dioxide (CO2), and methane (CH4), it has become essential to look forward the use of renewable or inexhaustible fuels to trim down the trouble on our non renewable fuels and for resolving the problem of emissions. In this work, performance and emission parameter were investigated on a single cylinder four stroke diesel engine. This engine was modified to run with Biogas &Diesel in dual fuel mode .The experimental results show that 25% diesel save at low load and emission of CO2,CO and HC slightly increases with increasing load. Exhaust gas temperature also increases with load in both fuel modes (Diesel as well as Diesel-Biogas).

KEYWORDS: C.I. Engine, Biogas, Dual fuel etc.

INTRODUCTION

Due to the increasing energy requirement day by day in the various field like that industry, transportation, lighting, cooking etc .so that fossil fuel resources inevitably necessitate for the best possible utilization of exhaustible fossil fuel and non-renewable energy resources. Almost certainly in this century, it is believed that petroleum products and crude oil will become very limited and costly to find and produce .According to the energy department our country imported huge amount of crude oils from gulf countries and prices are very fluctuant, hence, the public interests are increasing in the field of various alternative fuels (methanol, ethanol, biogas etc.) and biogas is one of the more important available sources to fulfill the energy demand. Biogas is simply made by the process of anaerobic digestion or fermentation of biodegradable materials such as biomass, manure, green waste (plants), municipal waste, house waste, crops and plant material. Biogas can also be cleaned and upgraded to natural gas standards and becomes bio methane (CH4). An overall valuation of the results indicated that the biogas and diesel dual fuel operation could be substituted for diesel fuel in engine possible to work satisfactorily under long term engine operation without any major difficulty. This thinking of biogas as a diesel fuel substitute is not new, but it is a very efficient and attractive alternative, particularly in countries having worked more on agricultural products and demand in petroleum resources. Biogas cannot be used to run a compression ignition (CI) engine directly due to its high self-ignition temperature (650°C). However, it can be utilized in a CI engine (Diesel engine) with the dual fuel-ling approach (DFM). The dual fuel engine is basically a modified CI engine. Dual fuel technology (DFT) primarily consists of two different fuels. One is primary fuel (Biogas) which is gaseous fuel on which the engine runs primarily and the other fuel is pilot fuel (Diesel) which is used for instigation of ignition.

Basic of Biogas: Bio-gas is a result of anaerobic decomposition of organic material by micro organisms in a moist environment and in the absence of oxygen. Its composition is a mixture of gases in which methane (CH4) and carbon dioxide (CO2) are in larger amount but it also contains some other constituents. This composition mainly dependent on the different type of plants and even can change in a certain plant regarding the location of the digester. Amount of long hydrocarbon chain materials in the digester, liquid content, exposure time, temperature, pressure and more

parameters can affect the biogas generation processes and change the methane (CH4) content of resulting the content of hydrogen sulphide (H2S) depends on the process and waste type.

BIOGAS COMPOSITION

Table1: Biogas composition

Component	Amount%
Methane (CH_4)	50-70
Carbon Dioxide (CO_2)	30-40
Hydrogen (H_2)	5-10
Nitrogen (N_2)	1-2
Water Vapour (H_2O)	0.3
Hydrogen Sulphide (H_2S)	Traces

Source (Karki et al, 2005)

PURIFICATION

Biogas can be use more efficiently in diesel engine after its purification. Now biogas can be used directly to generate power, but present in the large volume of carbon dioxide (CO2) reduces the heating value of the gas, increasing compression and transportation costs and limiting economic feasibility to uses that occur at the point of production. Purification is wider variety of uses, either for electricity and heat, or for vehicle fuels. For use as a fuel, purification to remove carbon dioxide (CO2) and hydrogen sulfide (H2S) is required, because present H2S corrodes vital mechanical components within IC engine sets and vehicle performance if it is not removed. Although the exhaust of engine in also harmful for the environment and human health. Biogas emits fewer amounts of nitrogen oxide, hydrocarbon and carbon monoxide than gasoline or diesel, and engines fueled by purified biogas are quieter. Refueling with biogas presents fewer environmental and health risks than refueling with gasoline or diesel, because it must required a small unit located at an owner's home or industry, minimizing the potential impacts if leaks or spills occur. Feasible biogas purification technologies exist for large-scale biowaste and sewage digesters, and the technologies for upgrading biogas, compressing, storing and dispensing biomethane are well developed. The following techniques are used for purification:

1. Scrubbing
2. Chemical Absorption
3. Pressure Swing Adsorption
4. Membrane Purification
5. Cryogenic Separation
6. Biological Processes

UTILIZATION

Today biogas applications are wider in the various fields because of its than diesel engines. availability and free of air pollution. Biogas is not limited in the only generates energy but also plays important role in waste management, environment cleaning and gives guarantee of continuous fuel supply in future. Conventionally biogas is consumed for cooking in India but with increasing faith in renewable energies. The biogas application area is widening.

List of biogas application

- Production of Heat& Steam
- Electricity Production
- Gas Engines
- Fuel Cells
- Vehicle Fuel
- Production of Chemicals
- Internal Combustion-CI&SI

DUAL FUEL TECHNOLOGY

Biogas generally has a high self-ignition temperature (650°C) hence; it cannot be directly used in a CI engine. So it is useful in dual fuel mode operating engines. The dual fuel engine is a modified diesel engine in which typically a gaseous fuel (biogas) called the primary fuel is inducted with air into the engine cylinder and biogas is a good mixing ability of air. The biogas and air mixture does not auto ignite due to high octane number. The biogas and air mixture does not auto ignite due to high octane number. A small amount of diesel, usually called pilot fuel is injected for better combustion. The primary fuel in dual fuelling system (DFS) is homogeneously mixed with air that leads to very low level smoke in the exhaust of engine. Dual fuel engine can use a different type of primary and pilot fuels. The pilot fuels are generally of high cetane number and zero octane number. Introduction of biogas usually leads to deterioration in performance and emission characteristics of the engine. The ignition delay of the pilot fuel (diesel) generally increases with the introduction of biogas and this will lead to move forward the injection timing. Injectors opening pressure and rate of injection also are found to play important role in the case of biogas as fuel in a dual fuelled engine, where vegetables oil is used as a pilot fuel. The percentage of CO2 in the biogas acts as diluents to slow down the combustion process in Homogenous charged compression ignition (HCCI) engines.

EXPERIMENTAL SETUP

The setup consists of single cylinder, four strokes water cooled diesel engine connected to a brake dynamometer and loading unit. It consists necessary instruments for measurements of various performance and emission parameters. The setup has standalone consisting of air box, fuel tank, hot wire anemometer, fuel measuring unit, etc. The fuel was injected into the engine from the diesel tank which is placed in the panel board. The burette was also positioned in the same panel board for measuring the quantity of fuel at particular time of interval. Biogas was admitted at constant flow rate to the engine directly from the digester through convergent divergent nozzle. All experimental works were performed in thermal engineering lab of UIT RGPV Bhopal (M.P.). Hot wire anemometer is used to measure the velocity of biogas, by which flow rate was determined.

Figure2: Experimental set at UIT -RGPV

Table 2 shows the specification of the engine

Parameters	Details
Make and type	Kirloskar
Speed	1500RPM(constant speed)
No. Of Cylinder	Single
Fuel Used	Diesel
No. Of Stroke	Four stroke
Type of Cooling	Waterr-Cooled
Fuel intake measurement	Calibrated burette
Air intake measurement	Air box
Dynamometer	Brake dynamometer
Exhaust gas calorimeter	Water cooled type

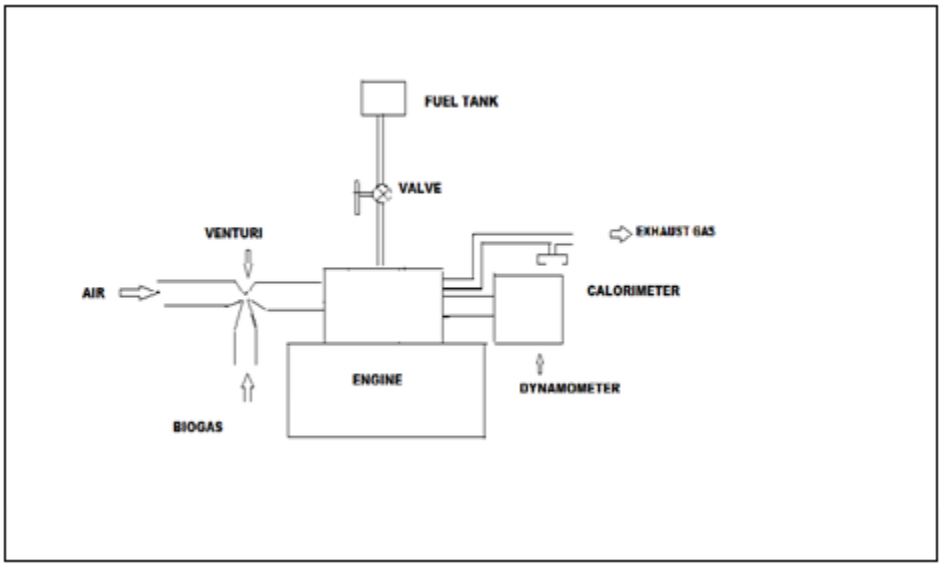


Figure 3: Block Diagram of Experimental Setup

Following additional attachment was used for Biogas operation:

- Biogas mixing device
- Hot wire anemometer

BIOGAS MIXING DEVICE

Basically biogas mixing device based on the carburetion principle. It is used to the homogenously mixing of air and biogas before enter to the intake manifold of the engine. In dynamics, a fluid's velocity must increase as it passes through a constriction in accord with the principle of continuity, while its static pressure must decrease in accord with the principle of conservation of mechanical energy. Thus any gain in kinetic energy a fluid may accumulate due to its increased velocity through a constriction is balanced by a drop in pressure. Due to drop in pressure venturi throat sucks more biogas from biogas digester. Fig 4 shown the schematic diagram of biogas mixer.

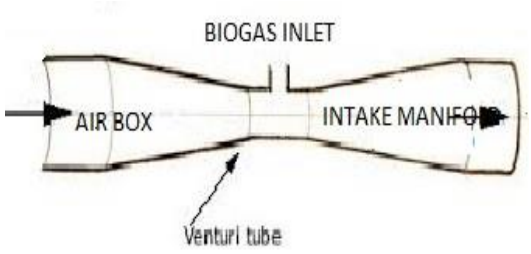


Figure4: Biogas mixer

HOT WIRE ANEMOMETER

Hot wire anemometer has plays an important role in the study of laminar, transitional and turbulent boundary layer flow. It is used to measure the velocity of biogas from the pipe line which connected to the biogas digester. Generally the common hot wire anemometer consists of a sensor, a small electrically heated wire exposed to the fluid flow and electronic equipment to perform the transformation of the sensor output into electrical signals. The hot wire anemometer working when the flow velocity passing the thin wire which is sensor, the convective heat transfer will change, wire temperature will change and increase the resistance in the wire. In this set up hot wire anemometer attached to the intermediate of the pipe which connected from the digester. When the biogas flow takes place shown the velocity of biogas. The principle of operation for the hot wire anemometer is shown in Figure: 5.

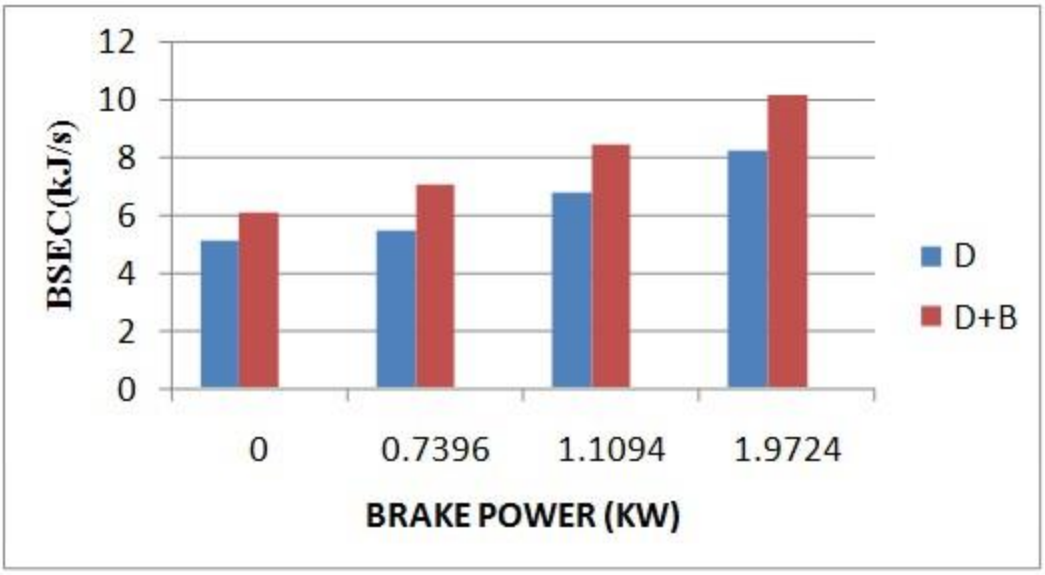
Figure5: Hot wire anemometer

RESULTS AND DISCUSSION

In this work, an effort has been made to compare the performance and emission characteristics of a CI engine when operated with neat diesel (D) and biogas diesel mixture (D+B). Loading arrangement is used to apply loads to the brake dynamometer. The burette setup is used to find out the consumption of fuel and hot wire anemometer is used for determining the flow rate of biogas.

Brake power vs. Brake specific energy Consumption

Fig 6 shows the variation of BSEC with BP for neat diesel and diesel-Biogas. The Brake specific energy consumption of the engine is increased when increase the engine load because biogas is low energy fuel. From the graph, it is observed that the fuel consumption of the engine is high at zero load and its further increases when biogas is used as the fuel and the diesel as the pilot fuel because the proportional replacement of the diesel by biogas is taken place.



6Figure 6: BRAKE POWER vs.BSEC

Brake power vs. Brake Thermal Efficiency

The Fig 7 shows the variation of Brake thermal efficiency with Brake power for neat Diesel and Diesel- biogas. The break thermal efficiency indicates the ability of the combustion system to accept the experimental fuel and provide comparable means of assessing how efficiently energy in the fuel can be converted into mechanical productivity. If we use biogas as fuel, then the brake thermal efficiency (BTE) will be lower when compared to diesel because due to present of carbon content in the biogas, lowers energy conversion in diesel fuel with biogas.

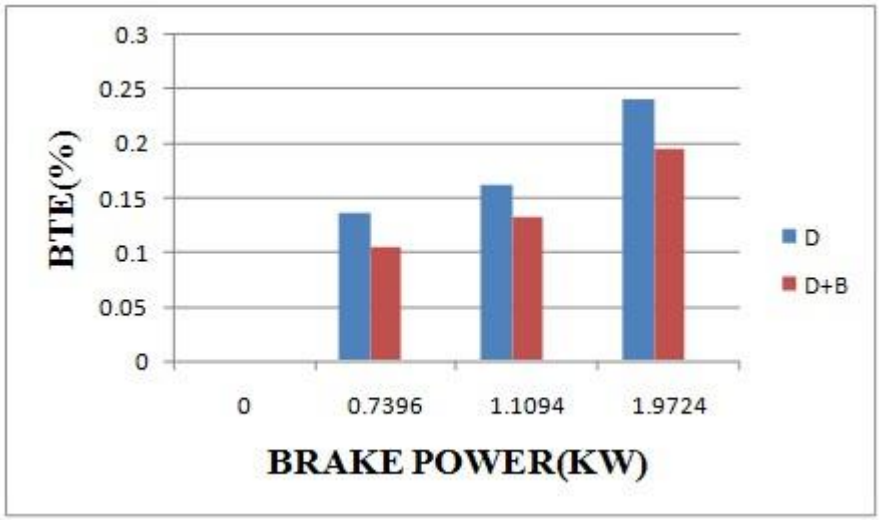


Figure 7: Brake power vs. Brake Thermal Efficiency

Emission analysis

Brakepower vs.CO Emission

The Fig 8 shows the variation of carbon monoxide (CO) emission in percentage volume with Brake power for biogas-diesel and neat diesel. In the exhaust emission the CO of biogas-diesel is more than that of neat diesel. In dual fuel mode, the CO emission gradually increases with the increase in load due to low calorific value and high carbon content that badly affects the combustion efficiency of the engine. The incomplete combustion, the CO is changed to CO2 due to low gas temperature.

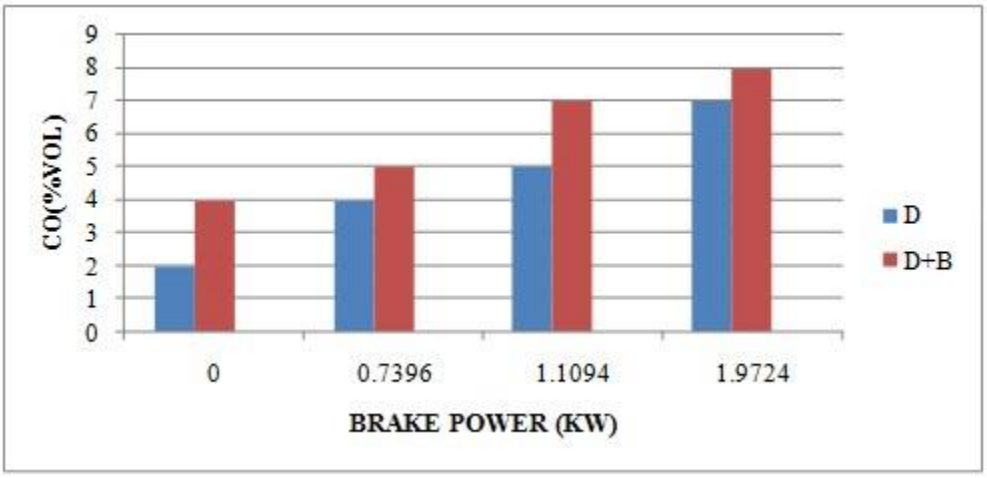


Figure8: Brake power vs. CO

Brake power vs. CO2 Emission

The Fig 9 shows the variation of carbon dioxide (CO2) emission in percentage by volume with Brake power for Biogas-Diesel and neat diesel. In the exhaust of the engine the CO2 emissions increase with an increasing percentage load (%); it show that the poor efficiency of the combustion chamber. The CO2 increases as the Brake power of the engine is increases; this is due to the increase of carbon content in the biogas. The oxygen content in the exhaust gas will decrease gradually, this is due to the complete combustion is taken place as the Brake power is increased. The percentage volume of CO increase due to the oxidation of the CO. The late burning of the mixture of diesel and biogas has caused more fuel to remain partially unburned. This increases the formation of carbon monoxide and decreases the proportion of the carbon dioxide level.

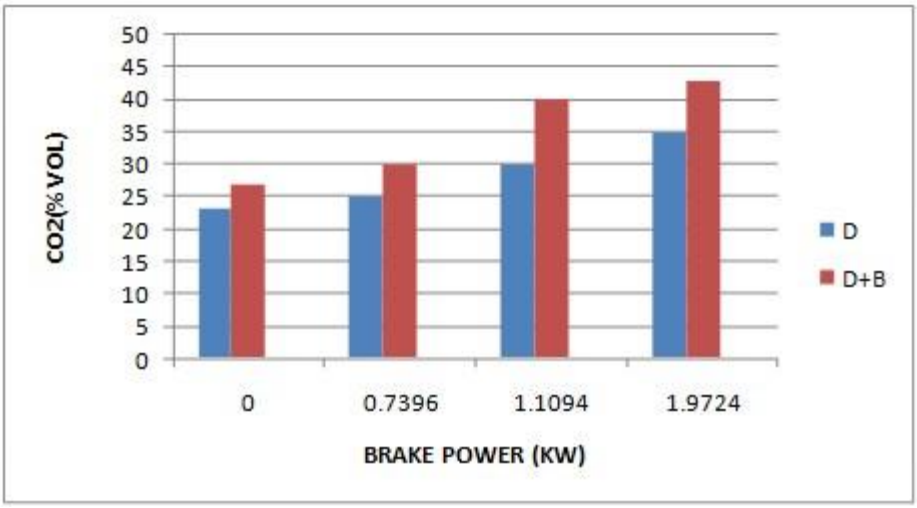


Figure9: Brake power vs.CO_2

Brake power vs. exhaust temperature

The Fig 10 shows the variation of exhaust gas temperature (°C) with Brake power for Biogas-Diesel and neat diesel. It can be seen from graph that the exhaust gas temperature increases with increasing the load in both cases, while it is higher in case of dual fuel than the diesel because excess energy supplied to the engine during dual fuel operation.

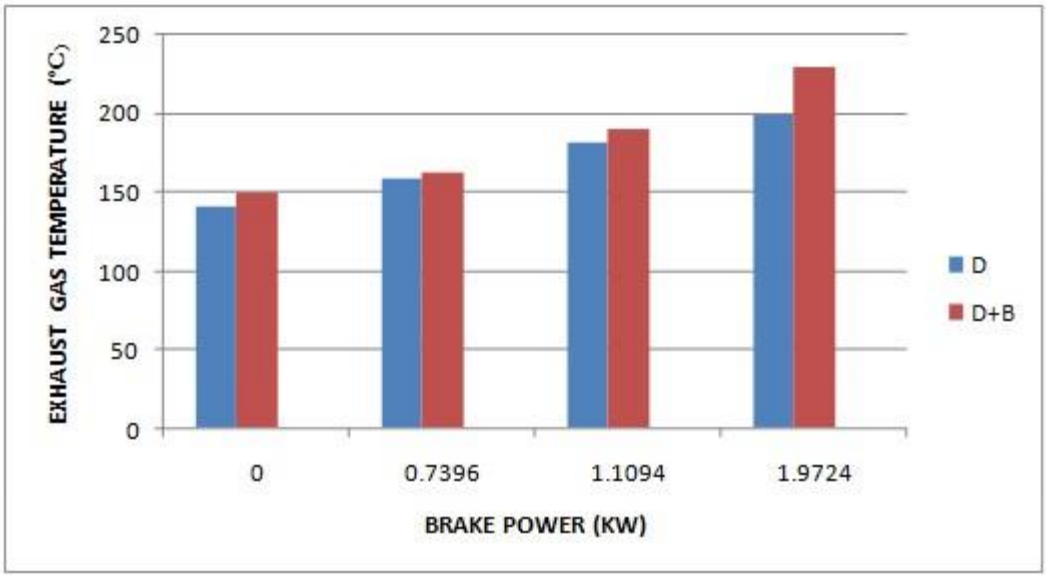


Figure10: BP vs. Exhaust gas temperature

CONCLUSIONS

In this study, the biogas is a renewable fuel which can be used in dual-fuel mode in the diesel engine without any modification to an engine. In addition to easy availability, it is renewable and cheap. The biogas can make a good substitute for diesel fuel. At equal power output situation, the dual fuel engine (Diesel-Biogas) performance is compared to that of baseline case. In this set up, Diesel engine performance experimentally investigated and the following conclusions may be drawn:

1) The use of biogas in diesel engines, as in collecting fleets, besides reducing the consumption of diesel used in approximately 25%, which ends up causing economic and environmental benefit for the place in which it is used.
2) The existence of CO2 in the biogas reduced the burning velocity, and thereby, deficient combustion that increased the BSEC and exhaust gas temperature .As well as this, the longer pilot ignition delay and high self-ignition temperature of biogas helped delaying the dual fuel combustion process and gives to the more expansion stroke (end stroke). Collectively all these factors are responsible for lowered the thermal efficiency.
3) The Brake Thermal Efficiency is decreased as the percentage of biogas increased as compared to conventional fuel (diesel fuel). This is due to lower energy contents in diesel fuel with biogas.
4) It is examine that dual fuel mode need higher fuel energy (due to their poor combustion of fuel-air mixture and lower calorific value) for producing same amount of shaft output compared to its diesel mode.

However, the emission quantities can be reduced by using the alternative fuels(Biogas),but the dissimilar characteristic of substitute fuels will never allow them to offer performances parameters equivalent to or better than diesel at standard diesel engine. Hence, taking into consideration the present study as a base line work, there is enough possibility for further research in future and optimizes the operating characteristics for the study of biogas dual fuel.

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