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Performance analysis of biogas premixed charge diesel dual fuelled engine

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Abstract : *This paper presents the technical performance measurements of biogas premixed charge diesel dual fuelled engine. A 4-stroke research diesel engine was used for the performance analysis. The performance parameters like engine brake power, brake specific fuel consumption, volumetric efficiency and brake thermal efficiency were measured and compared with conventional diesel with different proportion of biogas-diesel dual fuel (minimum flow 8kg/hr, intermediate flow 9.8 kg/hr and full flow 11.9 kg/hr). The average brake power 0.6 kW at lower load and 2.80 kW at higher load condition which is almost nearest to diesel operation. brake thermal efficiency lower at low load and it is increased with increase in load than neat fuel operation(Around 16% to 17% at lower load and 40% at higher load condition) .The value of maximum brake thermal efficiency is 40% with full flow (11.9Kg/hr) at higher load condition.SFC value of neat diesel 0.65 kg/kWh at lower load and 0.30 kg/kWh at higher load and dual fuel and dual fuel has 0.51 kg/kWh at lower load and 0.21 kg/kWh at higher load condition. The reference volumetric efficiency of engine has almost similar volumetric efficiency when using dual fuel and diesel (about 80% at lower load and 78% at higher load). But with slight reduction is seen in using dual fuel operation (about 79% at lower load and 77% at higher load).*

Keywords : *Biogas, compression ignition, dual fuel, renewable energy*

I. Introduction

The enormous growth in industries and increase in population are the main reason for heavy depletion of fossil fuel. Since most of the energy resources are limited in nature, thus, the need for different energy resources mixing utilizations has been proposed as an alternative solution to the problem. Gaseous fuels like natural gas, biogas and producer gas have been explored as alternative to petrol and diesel to reduce the petroleum import burden. Natural gas is a fossil fuel that has been used and investigated extensively for use in spark ignition (SI) and compression ignition (CI) engines .The ‘‘dual-fuel Concept’’ is one of them that uses liquid and gaseous fuels in an engine. This so-called dual fuel operation was studied by many others, using various fuels Indicates that, it is possible to operate most of the dual-fuel engines, either on gaseous fuels, such as biogas/natural gas with diesel/biodiesel or wholly on Liquid fuel injection as a diesel engine thus tends to retain most of the positive features of the diesel operation at full load. Dual-fuel engines achieved higher efficiency without significant particulates and NOx emission (1).

Most studies indicate as almost all combustion devices are easily adaptable to the use of gaseous fuels, such as biogas for power production (1).Biogas can be used in both heavy duty and light duty vehicles(3). 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. Diesel engines require combination of biogas and diesel oil for combustion. 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 CO2, H2S and water vapor. For use of biogas as a vehicle fuel, it is first upgraded by removing impurities like CO2, H2S and water vapor. 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 (2). However, up to 40% CO2 in biogas did not deteriorate engine performance, but the performance improves with 30 %(1).

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 (3). Use of biogas as an engine fuel offers several advantages. Biogas being a clean fuel causes clean combustion and reduced contamination of engine oil. 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 (2). 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. Biogas can also be used in dual fuel mode with vegetable oils as pilot fuels in diesel engines. Introduction of biogas normally leads to deterioration in performance and emission characteristics. The performance of engine depends on the amount of biogas and the pilot fuel used [(4)].

As seen in the literature review, most of the dual fuel engine performances studied by using diesel, biodiesel or their blends with NG or CNG. In addition, the recent study of pure diesel with synthetic biogas is also claimed as the first work in this regard. Thus, as the most studies, including, reported more problems of using PPO in CI engine and actual biogas has also additional chemical compositions than the synthetic biogas: CH4, CO2, unavoidable content of 2-8% water vapor and traces of O2 N2, NH3, H2, and H2S. Therefore, the present work is focused to assess the technical performances of pure jatropha oil-diesel blending with actual field biogas in a modified dual fuel diesel generator, and hence, this work presents the first measured results on combination of jatropha oil-diesel blends and the actual biogas to the author's knowledge.

Biogas is becoming an attractive source of energy in many nations across the globe because it can be used to fuel a car or to power city buses. It has been variously used for heating purposes and/or electricity generation. Furthermore, the up gradation of biogas to bio-methane and feeding into the natural gas grid is an effective way of integrating the biogas into the energy sector [(5)]. It can be successfully used as substitute for natural gas and as transportation fuel. In view of above context, the objective of the present work was to determine and analyze the suitability of utilization of biogas and methane enriched biogas in stationary diesel engine with reference to the diesel fuel.

II. Experimental Setup and Technical Method

Selected fuels and their properties

The fuels selected for evaluation and analyze of engine performance were methane enriched biogas and pure diesel oil. Some important fuel properties of these selected gaseous fuels are given in Table-1. A substantial change in methane and carbon dioxide contents in the produced biogas does not take place unless there is drastic change in environmental operating parameters and/or change in quality of input feed material. However, there is always a little variation in composition of produced biogas with time according to the activities of anaerobic bacteria. Methane enrichment of biogas originally containing 65% methane and 32% carbon dioxide with 3% other gases was carried out using a water scrubbing system. 95% purity methane was obtained at the outlet when the system was operating at 1.0 MPa operating column pressure and 2.5 m3/h biogas flow rate. Methane enriched biogas was stored in 500 l mild steel tank at pressures lower than 1.0 MPa. Further, it was supplied to the engine by using a pressure reducing valve.

Table.1 Composition and constituent of biogas

Constituent	By volume	By mass
CO_2	19%	37.28%
N_2	6.5%	8.14%
O_2	1.5%	2.15%
CH_4	73%	52.34%
H_2S	20ppm	
Density	0.9145kg/m^3(273K.1atm)	
(A/F) s, CH4	17.23	

Table.2 Properties of biogas and diesel

Property	Biogas	Diesel
Relative density	1.11	0.837
Flame speed (cm/s)	25	-
Stoichiometric A/F (Kg of air/kg of fuel)	17.23	15.0
Auto ignition Temperature (C)	650-750	250-300
LHV	26.17 MJ/kg	42 MJ/kg

III. Experimental Setup

The setup consists of single cylinder, four stroke, multi-fuel, research engine connected to eddy type dynamometer for loading. The specification of the research engine is given in table-3. The operation mode of the engine can be changed from diesel to petrol of from petrol to diesel with some necessary changes. In both modes the compression ration can be varied without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement.

The injection point and spark point can be changed for research tests. Setup is provided with necessary instruments for combustion pressure, Diesel line pressure and crank-angle measurements. These signals are interfaced with computer for pressure crank-angle diagrams. Instruments are provided to interface airflow, fuel flow, temperatures and load measurements. The set up has stand-alone panel box consisting of air box, two fuel flow measurements, process indicator and hardware interface. Rota meters are provided for cooling water and calorimeter water flow measurement. A battery, starter and battery charger is provided for engine electric start arrangement.

The setup enables study of VCR engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio, heat balance and combustion analysis. Lab view based Engine Performance Analysis software package "Engine soft" is provided for on line performance evaluation.

Fig.1 Single cylinder, four stroke, multi-fuel, research engine connected to eddy type dynamometer

Table.3 Engine specification

Model	TV1
Make	Kirlosker Oil Engines
Type	Four stroke, Water cooled, Diesel
No. of cylinder	One
Bore	87.5 mm
Stroke	110 mm
Combustion principle	Compression ignition
Cubic capacity	0.661 liters
Compression ratio 3 port	17.5:1
Peak pressure	77.5 kg/cm^2
Max. Speed	2000 rpm
Min. idle speed	750 rpm
Min. operating speed	1200 rpm
Fuel timing for std. engine	0 to 25 BTDC
Connecting rod length	234 mm

Biogas is used in dual fuel mode with diesel as pilot fuel in diesel engines. Introduction of biogas normally leads to deterioration in performance and emission characteristics. The performance of engine depends on the amount of biogas and the pilot fuel used. The following schematic diagram shows the dual fuel operation in diesel engines.

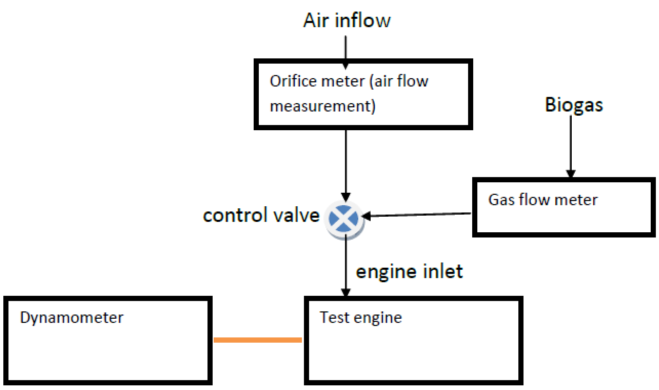

Fig.2 Line diagram of dual fuel

IV. Result And Discussion

In this section, the results of dual fuel operation of Biogas-Diesel is compared with neat diesel are presented.

Brake power

Initially engine run with the diesel fuel in unmodified diesel engine attached with eddy current dynamometer arrangement. After some time engine run with dual fuel operation and take the report of the readings at different loading condition with different proportion of biogas premixed with diesel. The variation of brake powers with load is shown in Figure.

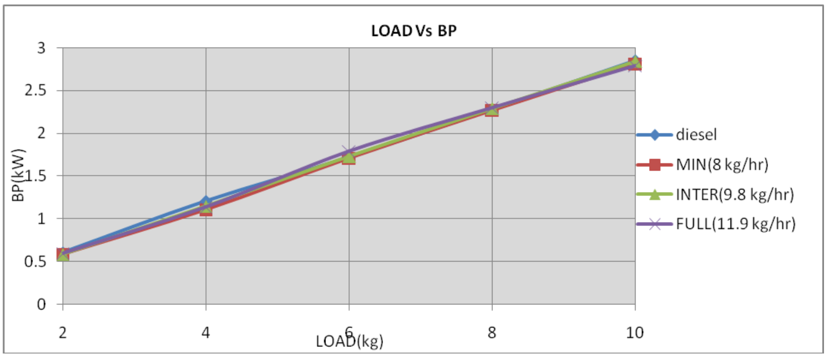

Fig.3 Refrence brake power measurement

Figure-3.shows that engine has almost similar brake power operated when minimum (8Kg/hr), intermediate (9.8Kg/hr) and full (11.9Kg/hr) flow of biogas premixed charge with diesel and only diesel fuel. (0.59 kW in lower load and about 2.80 kW at higher load).but slight reduction brake power with the minimum flow (8.0Kg/hr) (1.11kW at lower load).

Thermal efficiency

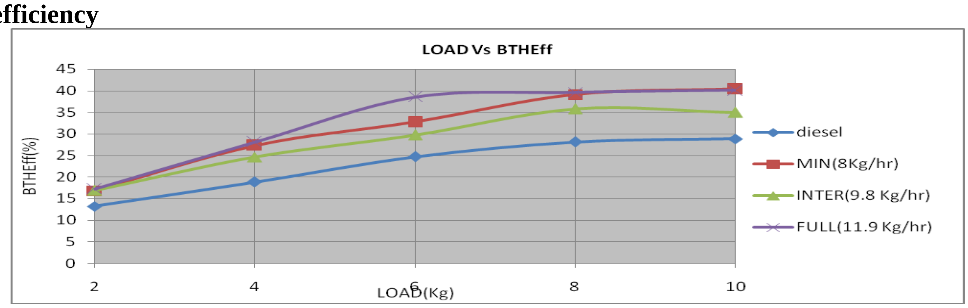

Fig.4 Refrence thermal efficiency measurement

The variation of brake thermal efficiency with load is shown in figure-4. It is observed from the figure in dual fuel mode the brake thermal efficiency lower at low load and it is increased with increase in load than neat fuel operation (Around 16% to 17% at lower load and 40% at higher load condition) .The value of maximum brake thermal efficiency is 40% with full flow (11.9Kg/hr) at higher load because the net heat supplied by full flow of biogas is decreased and the produced brake power remain almost constant.

Specific fuel consumption

From figure -5.it is observed that specific fuel consumption is deceased from lower load to higher load condition at all proportion of biogas which is premixed with diesel. The specific fuel consumption difference between dual fuel and neat fuel is decreased from 0.14kg/kWh to 0.04kg/kWh from lower to higher load condition. (SFC value of neat diesel 0.65 kg/kWh at lower load and 0.30 kg/kWh at higher load and dual fuel and dual fuel has 0.51 kg/kWh at lower load and 0.21 kg/kWh at higher load condition).

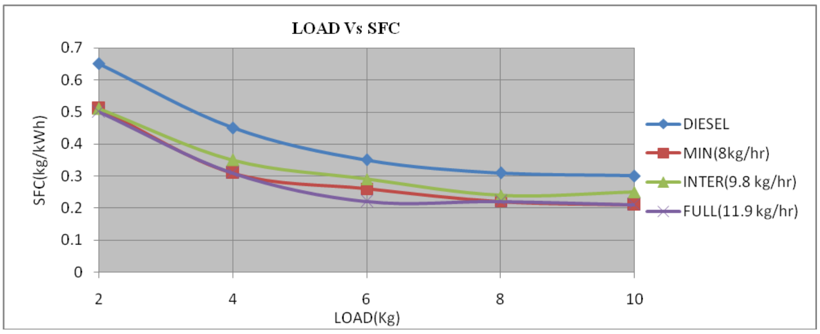

Fig.5 Reference specific fuel consumption.

Volumetric efficiency

The reference volumetric efficiency in figure shows that engine has almost similar volumetric efficiency when using dual fuel and diesel (about 80% at lower load and 78% at higher load). But with slight reduction is seen in using dual fuel operation (about 79% at lower load and 77% at higher load) But, in general the volumetric efficiency shows slight reduction with the increasing loads.

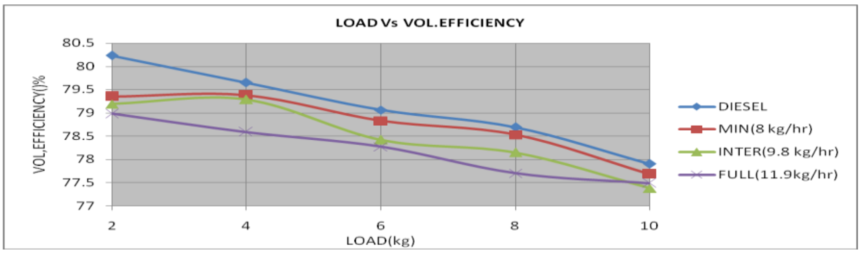

Fig.6 Refrence volumetric efficiency measurement

V. Conclusion

As a first step of this study, accordingly reference performance measurement of diesel and dual fuel achieved almost similar performance result in the measured parameter (Mechanical Efficiency, thermal efficiency, specific fuel consumption and volumetric efficiency).so that this study concluded that the used of biogas premixed charge diesel dual fuelled engine.

In the subsequent dual fuel tests, the mechanical efficiency, brake thermal efficiency and volumetric efficiency is increased by 1% to 2%, 3% to 12% and 1% respectively and specific fuel consumption is decreased about 0.09 kg/kWh to 0.14 kg/kWh.

References

[1]. Ahmed, Kamil, Balewgize Amare, and A. Venkata Ramayya. "Experimental Investigation On Thermal Efficiency Of Diesel Engine With Jatropha-Diesel Blend With Biogas." *International Journal of Engineering* 2.7 (2013).

[2]. N.H.S.Ray, M.K.Mohanty and R.C.Mohanty, "Biogas as Alternate Fuel in Diesel Engines: A Literature Review" *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)* (Sep. - Oct. 2013).

[3]. Debabrata Barik, S. Murugan," Production and Application of Biogas as a Gaseous Fuel for Internal Combustion Engines" *International Journal of Engineering Research & Technology (IJERT)* Vol. 1 Issue 7, September - 2012 ISSN: 2278-0181

[4]. Phan Minh Duc and Kanit Wattanavichien," Study on biogas premixed charge diesel dual fuelled engine" *Energy Conversion and Management* 48 (2007) 2286–2308.

[5]. R. Chandra a, V.K. Vijay b, P.M.V. Subbarao cand T.K. Khura a," Performance evaluation of a constant speed IC engine on CNG, methane enriched Biogas and biogas" *Applied Energy* 88 (2011) 3969–3977.