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Experimental Investigation on CI Engine to study the Emission Characteristics Using Biogas-Diesel as a Dual fuel

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Abstract: Biogas produced by the anaerobic digestion process using various organic wastes is an alternative partial substitution of fossil fuel due to the renewable resources that are widely available. This work is to determine the emission characteristics of CI engine using biogas and diesel in dual fuel mode. To determine the emission characteristics such as hydrocarbon, carbon monoxide, oxides of nitrogen and carbon dioxide using biogas-diesel for practical use by suitable modification on engine intake system. In this work, engine first operated with diesel mode by running the engine at a constant rated speed of 1500 rpm and varying the load between no load to 80% of the full load condition. To determine the emission characteristics, different set of readings were taken by charging the engine with different ratios of biogas and diesel for the above speed and load condition. The obtained emission results reveals that biogas-diesel mode shows less when compare to diesel mode. The results suggest that the engine operating with 80% biogas – 20% diesel mixture offers low emission than any other secondary fuel. The experiment results shows when engine operated with richer biogas-diesel than that of diesel-biogas mixture is better when compare to other mixing ratios under the same operating condition.
Keywords : Anaerobic digestion, biogas, dual fuel, compression ignition engine, exhaust emissions characteristics.

Introduction

Diesel engines are widely used as power source for automobiles due to their high efficiency, excellent fuel economy and low regulated emissions of unburnt hydrocarbon, carbon monoxide and carbon dioxide [1].However diesel engines generally exhaust a larger amount of particular matter and oxides of nitrogen emissions [2]. Due to the depletion of conventional source of energy at a faster rate and also emission from CI engine raised important issues on environmental problems. There is a need to exploit the renewable energy resources for power generation. Among the various renewable energy resources biogas by anaerobic digestion process of biomass such as manure, green waste, plant waste, municipal waste and crop waste play an important role to meet the energy demand [3]. Biogas also a clean and upgraded to a biomethane gas ,biogas constitute various composition such as methane(60-70%),carbon dioxide(30-40%), nitrogen less than 1% and traces of other gases[4]. Impurities in biogas such as CO_2 can be removed with the help of calcium chloride filter. The percentage of moisture in biogas can be eliminated with the help of silica gel filter resulted in methane rich gas. Methane is a main component of biogas due to its higher octane rating and auto ignition temperature. It is appropriate for engines with high compression ratios. The carbon content of biogas relatively low when compare to diesel fuel results in decrease the emission characteristics [5]. Biogas can be used as an alternative partial substitution with diesel with minimum engine adjustment and modification. Biogas is mixed with air was injected during the intake process by gas injector (gas kit) installed in the intake pipe. The engine operated with

biogas- diesel can be converted to a fumigated dual fuel engine which is more practical and efficient method [6]. At the end of compression stroke, diesel fuel is injected to ignite the mixture for proper penetration and evaporation to achieve. The flow rate of gas fuel is controlled by different valves and the mass was injected according to the engine speed and load at constant injection timing [7]. The main aim of this experimental investigation is to study the CI engine operated with biogas-diesel as dual fuel and to evaluate the emission characteristics for direct injection in CI engine using diesel and different ratios of biogas-diesel as dual fuel mode [8].

Experimental analysis

The objective of this study is to evaluate the emission characteristics of biogas-diesel fueled CI engine. The obtained results should be used to compare with the engine operated with the conventional fuel of diesel. Biogas used as fuel for engine was generated from 1 m^3 capacity biogas plant. The digester is made up of PVC material with floating drum type with 700 litres gas holder capacity. The digester is operated by a continuous process with mesophilic temperature range 25ºc-35ºc and charged with cow manure mixed with water by waste/water as 50:50 ratio. The digester slurry was charged with 20% inoculums and maintained with waste/volume as 50:50. The initial slurry pH was adjusted to optimum pH value of 7[9]. Other important parameters are maintained for continuous biogas production from plant. Biogas produced from the plant is fed to the engine inlet manifold. Before supplied to the inlet manifold of the engine, biogas is upgraded by the process of reducing CO_2 and moisture content.

Experimental setup:

The experimental investigation was conducted in the Department of Mechanical Engineering, Annamalai university. In a single cylinder CI engine of 5kW with rated speed of 1500 rpm, water cooled engine was used. The schematic view and the photographic view of experimental setup is illustrated in Fig.1 and Fig.2 respectively. The detailed specification of the engine is given in the Table 1. The engine is cooled by water cooling system fitted in the engine itself.

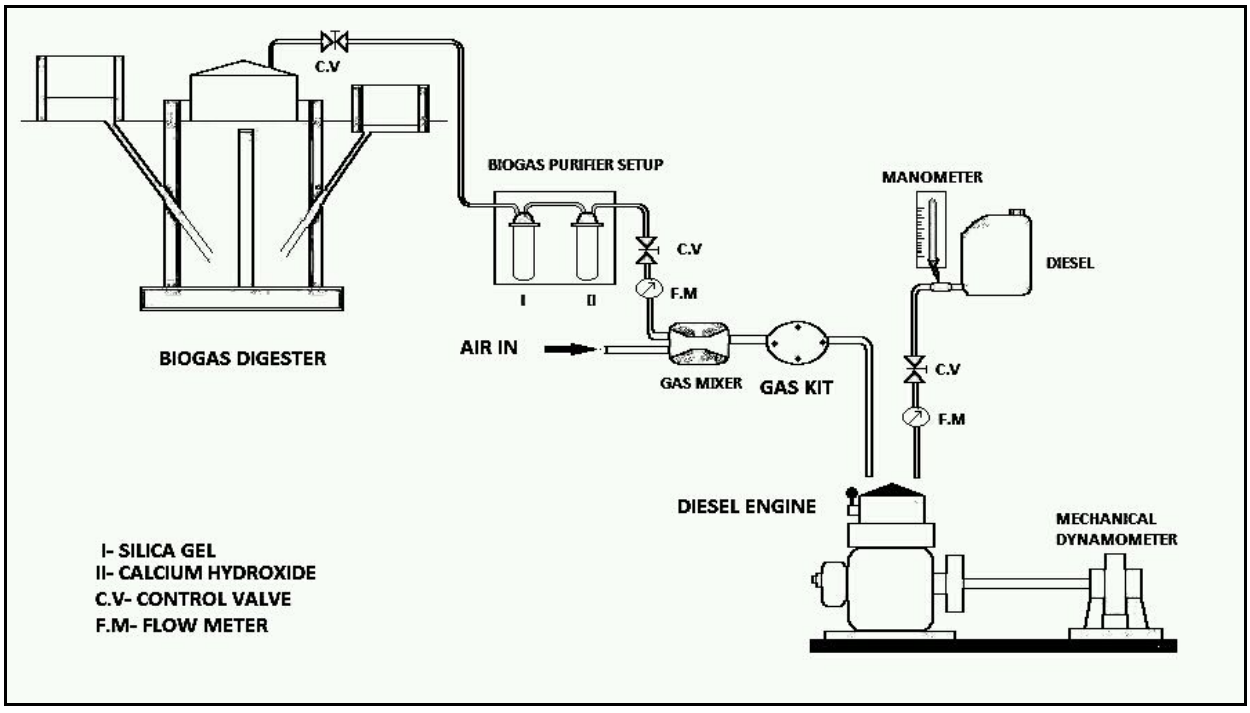

Fig 1. Schematic view of experimental setup

Fig 2. Photographic view of experimental setup

Table 1. Engine specifications

Engine	Kirloskar
Type	Water cooled
BHP	5kW
No. of cylinders	1
Bore	87.5
Stroke	110mm
Rated speed	1500rpm
Combustion	Compression ignition

The engine intake manifold is provided with T-joint to supply biogas plus airs are mixed in a single chamber [10]. Mass of diesel was supplied to the engine measured with the help of manometer provided in the setup. Biogas used in the test was supplied from the biogas plant. By compressing the floating gas holder pressurized biogas was fed to the inlet engine manifold. The gas was upgraded through purification to reduce CO_2 and moisture content for enriching the percentage of methane [11]. The variation of intake air mass flow and biogas mass flow can be increase with respect to the engine load condition can be varied with the help of different setup valves .The properties of biogas were also compared along with diesel shown in the Table 2.

Table 2. Properties of Biogas and Diesel

Property	**Biogas**	**Diesel**
Cetane number	-	50
Heating value(MJ/Kg)	24.5	45.9
Viscosity@40°c	-	3.34
Specific gravity@15°c	0.001	0.830
Sulphur content(% wt.)	0.12	0.037

Experimental procedure

The experiment was carried out with conventional CI engine and the engine was kept running at a constant rated speed of 1500rpm using a mechanical(rope brake friction type) dynamometer. When the engine reached the operating temperature, the test was conducted by varying the load from no load, 20%, 40%, 60% and 80% to the full load condition of the engine and the brake torque corresponding to each driving condition was measured by applying load on mechanical dynamometer [12]. The engine was running at an idle condition for a period of 30 minutes time. Emission tests were carried out with diesel as sole fuel first and then the engine

run with dual fuel of biogas-diesel with different ratios. Emission Readings were taken for diesel and diesel with biogas (diesel 80% + biogas 20%, diesel 60% + biogas 40%, diesel 40% + biogas 60% and diesel 20% + biogas 80%) under different load conditions. The exhaust emission characteristics such as hydrocarbon, carbon monoxide, carbon dioxide and oxides of nitrogen were measured for each fuel and compare with various test conditions [13]. To reduce the effect of dispersion in the readings, each set of reading was repeated in two times.

Results and discussion:

The experimental result suggested when the engine test was conducted at the same conditions with biogas and diesel by keeping the engine speed kept constant and varying the load condition from no load condition to 80 % of load. The exhaust emission level reported higher when the engine fueled with diesel alone when compare to the engine runs with dual fuel as biogas and diesel. The emission characteristics such as HC, CO, NO_X and CO_2 level was reported more in the case of diesel as a fuel [14]. The effect of exhaust gas temperature in the case of dual fuel combustion as reported higher when compared to diesel.

Carbon dioxide emission:

Fig.3 shows the variation of CO_2 emission with respect to different load conditions. It is clearly observed CO_2 concentration in the exhaust slightly increase in the case of diesel alone for all the load condition when compare to dual fuel operation of diesel and biogas. Even though the availability of CO_2 in biogas composition is more while combustion of biogas-air mixture emits less CO_2 than the burning of diesel-air mixture. This is due to diesel is hydrocarbon rich fuel.

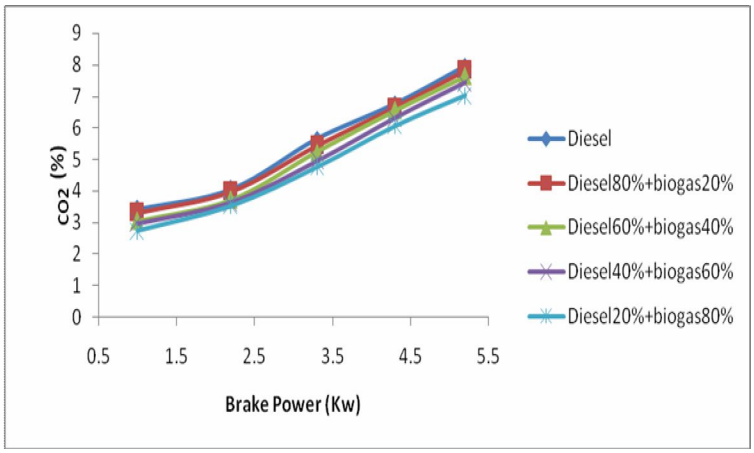

Fig.3 Variation of Brake Power Vs CO_2 emissions

The result clearly shows the emission increases when the percentage of diesel level also increases in the dual fuel mode. But interestingly 40% diesel + 60% biogas reported has higher CO_2. This may be due to the purification of biogas process cannot be done properly. The experimental result shows that the conversion of methane into carbon dioxide in the combustion products of biogas-air is less than that of diesel operation and this contributes to reduce green house gas effectively.

Hydrocarbon emission:

The Fig.4 shows the variation of hydrocarbon with respect to the different brake power. It is clearly observed from the fig. that the hydrocarbon emission is more in the case of diesel fueled engine. Nearly 20% more hydrocarbon exhaust emission reported higher when compared to dual fuel operation. In both the conditions HC emissions increases steadily when load of the engine increases. This is due to combustion temperature is higher and also the percentage of hydrocarbon is more using diesel than the dual fuel mode.

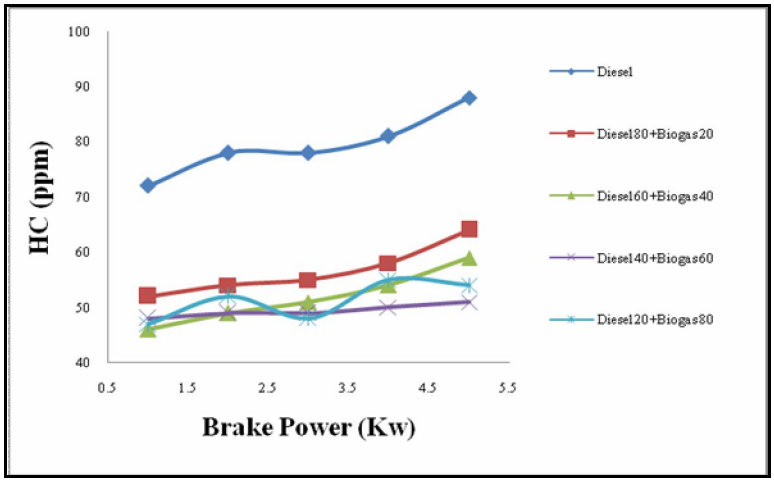

Fig.4 Variation of Brake Power Vs HC emissions

Oxides of nitrogen:

The Fig.5 shows when engine load increases from 20% to 80% both concentration of NO_X from exhaust of engine using diesel and biogas + diesel also increases which is theoretically correct. This is because at higher load condition that combustion temperature is higher emits more NO_X emission. As the engine load increases the NO_X concentration of all test conditions are increased steeply. Significantly lower NO_X emission was emitted under diesel-biogas fueled engine. This is due to higher calorific value of diesel than biogas.

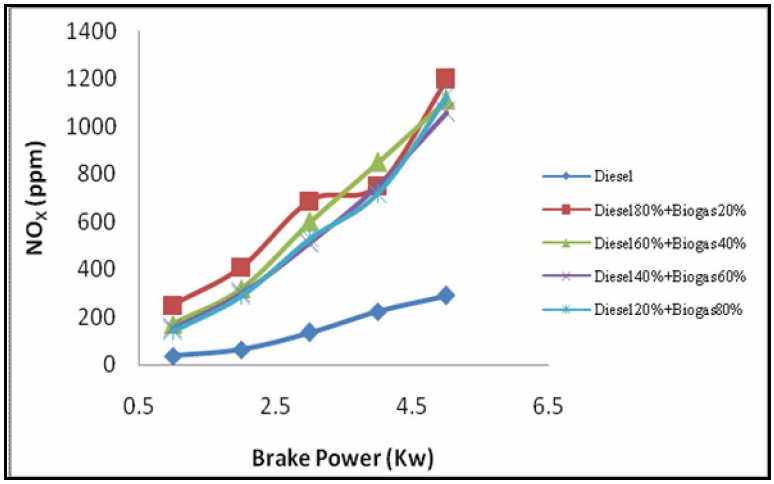

Fig.5 Variation of Brake Power Vs NO_x emissions

Carbon monoxide:

CO emission from diesel combustion emits somewhat low and roughly constant level of emission nearly equal to the dual fuel combustion for all load conditions as shown in Fig. 6. This is due to the lower stoichiometric ratio of air is less in case of dual fuel mode. However when compare between diesel and dual fuel combustion, the emission of CO considerably increasing with respect to increase the load.

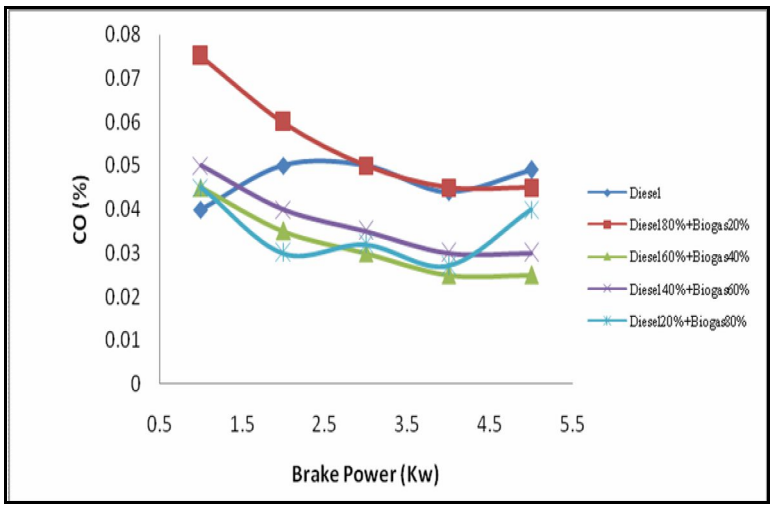

Fig.6 Variation of Brake Power Vs CO emissions

Exhaust gas temperature:

Fig. 7 shows the variation of exhaust gas temperature increases along with the increase of load in both the conditions. The combustion temperature is higher in the case of diesel reported slightly more when compare than that of biogas-diesel. Due to the lower calorific value of biogas reduce the exhaust gas temperature when the dual fuel burning of engine. Biogas reduces the temperature of biogas-diesel when burn.

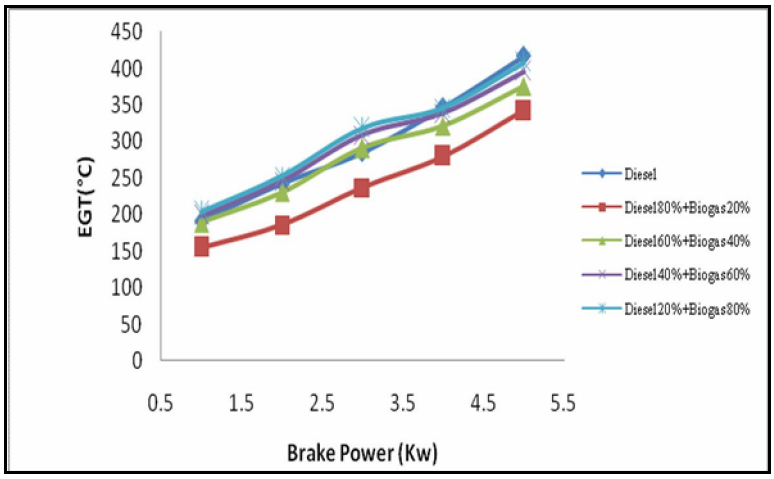

Fig. 7 Variation of Brake Power Vs EGT

Conclusion:

In this experimental study the engine exhaust emission test operating on diesel and dual fuel mode. By maintaining the rated speed of the engine constant and varying the load conditions has been carried out. In the dual fuel mode, by varying the ratio of biogas and diesel at different proportions, the experimental investigation also carried out. The result suggested the following conclusions

1. The efficiency of the engine may be increased using dual fuel arrangement.
2. 50% of diesel can be saved by using biogas-diesel as dual fuel in CI engine.
3. Hydrocarbon and carbon monoxide emission from dual fuel mode decreases as the percentage of biogas increase in dual fuel as compared to the conventional diesel fuel.
4. 80% diesel+20% biogas emits low hydrocarbon, carbon monoxide and NO_x.
5. Exhaust gas temperature increases with respect to the increase in load for all the cases.

References:

1. G.A. Karim, a review of combustion processes in dual fuel engine – the gas diesel engine, progress in energy and combustion science 6(1980)277-285.
2. Seung Hyun Yoon , Chang Sik Lee, Experimental investigation on the combustion and emission characteristics of biogas-biodiesel dual-fuel combustion in a CI engine 92(2011) 992-1000
3. C.Tricase, M.Lombardi, State of the art and prospects of Italian biogas production from animal sewage; technical-economic considerations, Renewable energy 34(2009) 477-485
4. C.Rahmouni, M.Tazerout, O.Le Corrre, A method to determine biogas composition for combustion control, SAE 2002-01-1708, 2002
5. R.J Crookes, Comparative biofuel performance in internal combustion engines, biomass and bioenergy 30(2006) 461-468
6. Borjession P Mattiasson B. Biogas as a resource efficient vehicle fuel. Trends Biotechnology 2008;26(1):7-13
7. N.N.Mustafi, R.R.Raine, A study of the emissions of a dual fuel engine operating with alternative gaseous fuels, SAE 2008-01-1394,2008
8. Debabrata barik, S. Murugan ,Production and application of biogas as a gaseous fuel for internal combustion engines International journal of Engg research and technology (IJERT) Vol.1 Issue-7.september-2012.
9. Vivekanandan.S and G.Kamaraj, Investigation on cowdung as co- substrate with pretreated sodium hydroxide on rice chaff for efficient biogas production, IJSAT Vol 1:No 4(2011)
10. V.P.Sethi, K.S.Salariya, Exhaust analysis and performance of a single cylinder diesel engine run on dual fuels, IE(I) Journal MC, Vol 85, April 2004,1-7
11. Shyam S. Kapdi, Virendra K.Vijay, Shivanahalli.K.Rajesh and Rajendra Prasad, 2006, Upgrading biogas for utilization as a vehicle fuel, asian journal on energy and environment, 7(04), 387-393
12. S.Swaminathan, J.M.Mallikarjuna, A.Ramesh,2010,An experimental study of the biogas diesel HCCI mode of engine operation, energy conversion and management, 4.8:2286-2308
13. Sorathia, Harilal S. Yadav, Hitesh J. Energy analyses to a CI engine using diesel and biogas dual-fuel a review study. International journal of advanced engineering research and studies.IJAER/Vol.i/Issue ii/January-March,2012/212-217
14. N.H.S Ray, M.K.Mohanty and R.C. Mohanty ,An investigation on performance characteristics of CI engine using biogas and diesel in dual fuel mode, IJSETR, Volume 3, issue 6, June 2014.

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