International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 05 | May -2017 www.irjet.net p-ISSN: 2395-0072

Performance Evaluation of Single Cylinder Diesel Engine in Dual Fuel Mode with Biogas as Primary Fuel and Diesel and Biodiesel as Pilot Fuel

Gund M.D. [1], Tamboli S.A.[2], Mohite V.R.[3]

[1]*Student , Dept. Of Mechanical Engineering, Imperial college of Engineering and Research*
[2] *Professor Dept. Of Mechanical Engineering, Imperial college of Engineering and Research*
[3] *Professor Dept. Of Mechanical Engineering, Bhivarabai Sawant Institute of Technology and Research*

Abstract - *In whole world energy demand is increasing day by day. It is very difficult to meet this high energy demand with coal and petroleum based fuels. The world wide awareness of environmental pollution and global warming caused by fossil fuels consuming at faster rate, the energy focus now shifting toward nuclear energy and renewable source of energy but nuclear energy required careful handling raw and waste material, so only option is left that is renewable source of energy. Biogas and Biodiesel are best alternative fuel. The fuel can be directly used in diesel engines with/without any modification in the existing engine. In the proposed work experiments will be performed on Kirloskar (AV1model) 4 stroke single cylinder diesel engine. The primary fuel, biogas was mixed with diesel and Biodiesel pilot fuel. The experiment were performed to measure various parameters like brake power, energy conversion efficiency, and emission such as percentage of CO, CO_2, HC particulate matter and NO_x in exhaust gas. The effect of diesel replacement on emissions was also studied.*

Key Words: **Dual fuel, biogas, biodiesel, diesel**

1. INTRODUCTION

In India 75% of population is engaged in agriculture related activities. This population is living in rural area, some at very remote areas. The centralised power generation systems are inadequate to meet the energy needs of the decentralised communities of rural India. Over past many years there has been phenomenal increase in the use of diesel engines in rural areas. Diesel engines are commonly used in power generation in rural applications, viz. tractors, irrigation pumps, generate sets chaff-cutters, crushers, mills etc., the demand for conventional fuel- diesel is increasing even at rural areas. On the other hand, the global huge pressure on energy issues and environmental pollution and global warming caused by burning fossil fuels has driven researchers as well as industrialists and governments to look for the other energy sources. This made essential that the electricity be introduced to rural areas in sustainable and environmentally sound way. Local production of fuel and generation of electricity is a sustainable option for rural electrification, which only can contribute to economic development and poverty reduction of rural areas. The diesel engines are most reliable and efficient combustion device, there is a growing need to adopt/modify such diesel engines for efficient and trouble free operation with biomass based gaseous fuels. Since biomass is available in huge amount in rural areas, it could be helpful to generate these fuels at the local sites; and using them to operate diesel engines. These fuels are also environment friendly because it increases renewable fuel consumption in transport but also because methane is considerably lower in carbon than ordinary diesel fuel. There could be two reasons to use these fuels. The first could be that the fuel can be directly used in the diesel engine without any change in the existing engine and other could be to use these fuels with minimal changes in engine. In the Present scenario, diesel engines are being extensively used for variety of applications in villages, while petrol engines or petrol operated generator sets are almost nil. **Pisarn Sombatwong et al. [1]** studied the effect of pilot fuel on the performance and emission of a dual producer gas diesel engine. Diesel was used as pilot fuel with biogas as primary fuel. The tests were conducted in natural aspiration mode and turbocharged mode with a mixing device of 10 times longer length in the latter case. It was found that the thermal efficiency in the second case was increased by 8% in second case. In second stage the by keeping the biogas flow rate fixed and reducing the pilot flow rate, it was noticed that the pilot quantity can be reduced to as low as 10%. This also resulted in lower exhaust gas temperature with turbocharger system. Better thermal efficiency in the experiment with turbocharger was probably due to better mixing of biogas with air. HC emissions were reduced notably with the system having longer mixing length. It shows a good mixing of air and biogas results in lower emissions and also with increased thermal efficiency. **Mohd Hafizil Mat Yasin et al. [2]** Studied of a diesel engine performance with exhaust gas recirculation (EGR) system fuelled with palm biodiesel. Experimental works using a multi-cylinder diesel engine with EGR and using Diesel-RK were performed at a constant engine speed of 2500 rpm in full load condition. The results showed that, from the experimental works, palm biodiesel significantly increased fuel consumption, increased NOx and slightly decreases in other emissions including CO2, CO, and unburned hydrocarbon (UHC). However, the use of EGR shows a

significant reduction in the NOx emission and exhaust temperature but increases in fuel economy, CO, CO2, and UHC emissions. **Saket Verma et al. [3]** studied the effects of varying composition of biogas on performance and emission characteristics of compression ignition engine using exergy analysis. Combustion analysis the in-cylinder pressure and rate of heat release data with respect to engine crank angles for diesel and dual fuel combustion modes at full load condition. It was found that the peak cylinder pressures with biogas dual fuel modes were always higher than that for diesel fuel mode. Peak in-cylinder pressure for diesel fuel mode was found 64.73 bar; and that for dual fuel modes: BG93, BG84 and BG75, it was found to be 71.56 bar, 70.15 bar and 68.84 bar respectively. It can be concluded that the high methane fraction in biogas equitable performance can be obtained in dual fuel operation without any major engine modifications. However, for improved performance with high CO2 concentration in biogas, significant changes in operating parameters are suggested. **Bhaskor J. Bora et al. [4]** investigated that 3.5 kW single cylinder, direct injection, water cooled, variable compression ratio diesel engine is converted into a biogas run dual fuel diesel engine by connecting venturi gas mixer at the inlet manifold. Performance analysis the CR is increased, the BTE in the dual mode improves. This is due to the fact that the temperature and the pressure rise with the increase in CR. This, in turn, increases the probability of more amount of biogas to undergo complete combustion. At 100% load, the BTE in diesel mode is found to be 27.76% whereas for the dual mode, the BTEs are found to be 20.04%, 18.25%, 17.07% and 16.42% at CRs 18, 17.5, 17 and 16, respectively. Although the BTEs of the biogas run in dual fuelled engine at different CRs are less as compared to the efficiency of the same engine run in diesel mode but the fact that stands out in favor of biogas run dual fuelled diesel engine is that biogas is a renewable fuel.

2 OBJECTIVES

The objective of this work is to study engine performance

a. Using diesel fuel,
b. Using biodiesel fuel,
c. Using Bio gas in dual fuel mode with diesel and biodiesel

The parameters that will be studied are as under,

1. Variation in break power
2. Brake specific fuel consumption
3. Indicated power
4. Thermal efficiency
5. Mechanical efficiency
6. Heat balance sheet
7. Volumetric efficiency

The engine performance will be compared based on Diesel and Biodiesel fuel performance against Bio Gas Diesel or Biogas Biodiesel fuel performance.

3 Experimental Setup

Table -1: Technical specifications for Kirloskar TV1 engine

Make	**Kirloskar Oil Engines**
Type	**Compression Ignition, Constant speed, Four Stroke ,Water cooled,**
No. of cylinder	**One**
Bore X stroke	**87.5 mm X 110 mm**
Cubic capacity	**0.661 litres**
Compression ratio	**17.5:1**
Peak pressure	**77.5 kg/cm^2**
Maximum speed	**2000 rpm**
Min. idle speed	**750 rpm**
Operating speed	**1500 rpm**

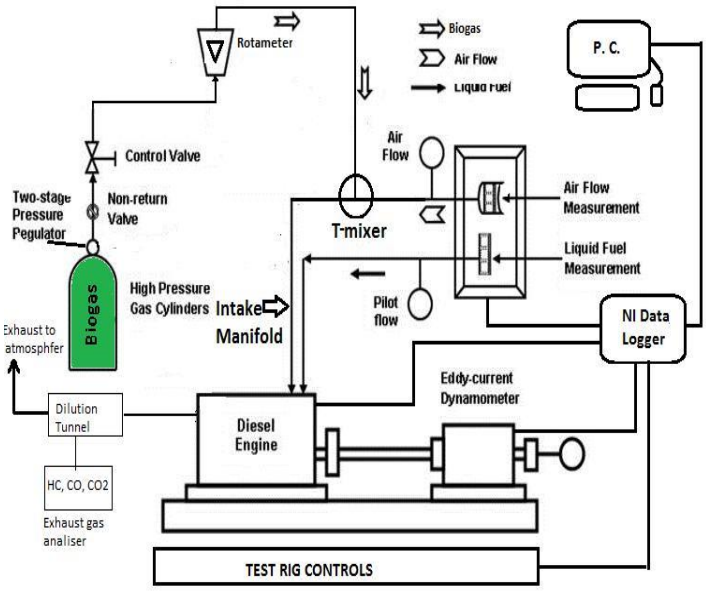

Figure 1: Block diagram of test setup

4 RESULTS AND DISCUSSION

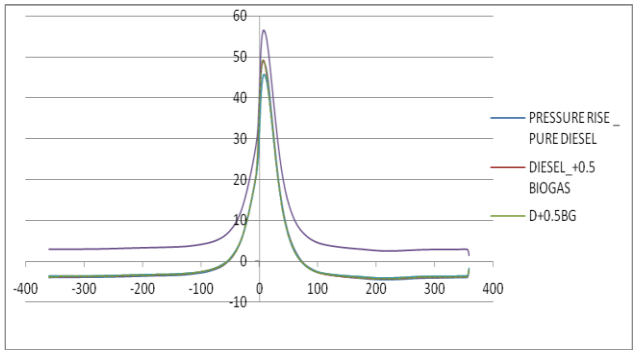

Fig 2: comparison of ICP vs CA (1.7 k W, 1500 rpm)

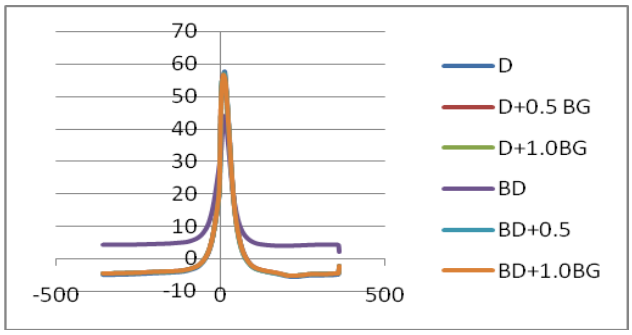

Fig 3: comparison of ICP vs CA (3.5 k W, 1500 rpm)

From figure 2 and 3 it is observed that, pressure rise is maximum for Biodiesel and diesel mode in both cases. The pressure rise is decreasing with increasing portion of biogas when engine is run in dual fuel mode.

Brake power

Variation of brake power with % of full load is shown in fig 4. It is observed that the dual fuel mode develops a brake power equivalent to the diesel dual only mode. At lower loads the power developed in different modes of operation is nearly the same. At higher loads it is seen that the dual fuel mode develops somewhat higher power than that of diesel being the difference very small.

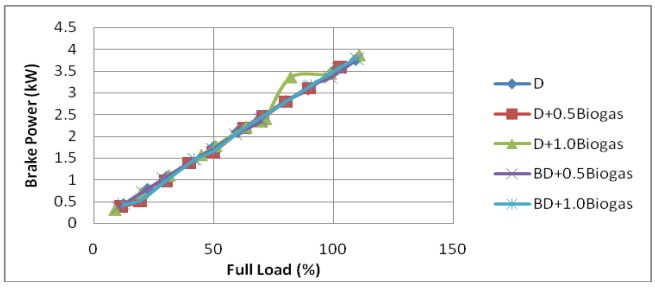

Fig 4: Variation of Brake power with % full load

Mechanical Efficiency

The variation of mechanical efficiency of the engine with % of full load is show in fig 5 was operated on diesel and dual fuel mode. In dual fuel mode, the engine develops an equivalent amount of power as developed in diesel mode. A keen observation shows that the mechanical efficiency is slightly higher than diesel except at few points. A maximum mechanical efficiency of 70.61% was obtained at slightly overloaded condition.

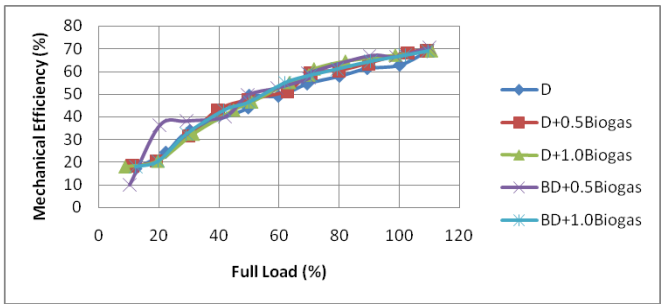

Fig 5: Variation of Mechanical Efficiency (%) with % full load

Brake Thermal Efficiency (%)

The variation of brake thermal efficiency of the engine with % of full load is show in fig 6 was operated on diesel and dual fuel mode. The maximum brake thermal efficiency was found at 90% of full load in dual fuel mode.

The flow rate for this particular case was 1.0m3/hr. This is achieved because of the biogas which is having 95% methane. Brake thermal efficiency in dual fuel mode is higher than that in diesel only mode at all the points. This is the advantages of methane present in biogas. It is clean fuel, and burns completely. This is in accordance with all engines operating in dual fuel mode with a gas as primary fuel.

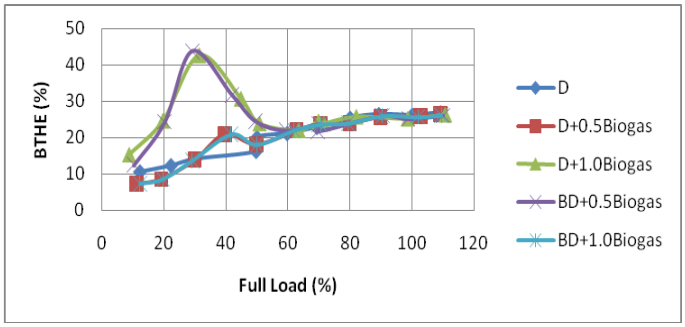

Fig 6: Variation of BTHE (%) with% full load

Volumetric efficiency

The variation of volumetric efficiency of the engine with % of full load is show in fig 7. was operated on diesel and dual fuel mode. In all cases it decreases with increase in the load. For both mode of operation, i.e. diesel only mode as well as dual fuel mode, the volumetric efficiency is

decreasing with increase in load. For biogas flow rate of 0.5 m3/hr, it is minimum. This is because of the nature of biogas induction method. For biogas flow rate of 0.5 m^3/hr, it is minimum. This is because of the nature of biogas induction method. As biogas is directly fumigated into the induction manifold using a T-joint mixer, it directly replaces/displaces the amount of air that is supposed to enter in the cylinder. This may affect other parameters like emissions, maximum peak pressure, and indicated work as amount of air required for complete combustion may decrease.

Hydrocarbon (HC) emissions

The variation of HC emission of the engine with brake power is show in fig 8 was operated on diesel and dual fuel mode. Unburnt hydrocarbons are the result of incomplete combustion. The figure shows that unburnt HC emissions are lowest in diesel only operation, and increases with higher flow rates of biogas. As biogas has methane as its main and only constituent, it is obvious that the unburnt part of the fuel will be more methanous in nature. A biogas flow rate of 1.0 m3/hr records maximum HC emissions.

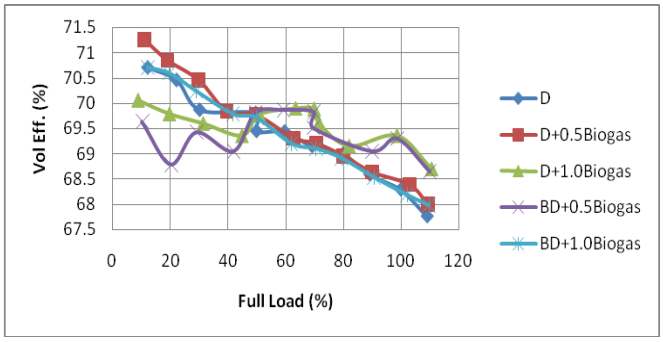

Fig 7: Variation of Vol eff. (%) with % full load

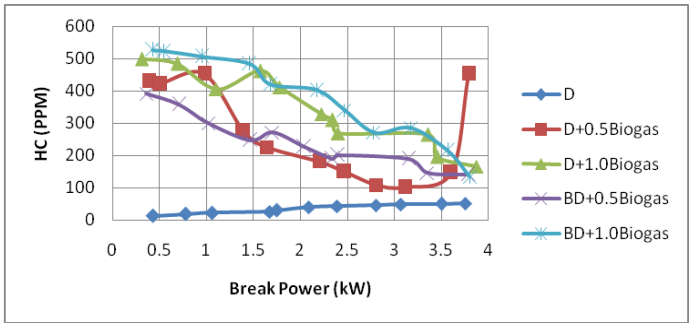

Fig 8: Variation of HC with Break power

Carbon monoxide (CO) emissions

The variation of CO emission of the engine with brake power is show in fig 9 was operated on diesel and dual fuel mode. There are two major causes of formation of CO emissions. The first one is the incomplete combustion due to insufficient supply of oxygen to combustion chamber and second one is the poor mixture formation.

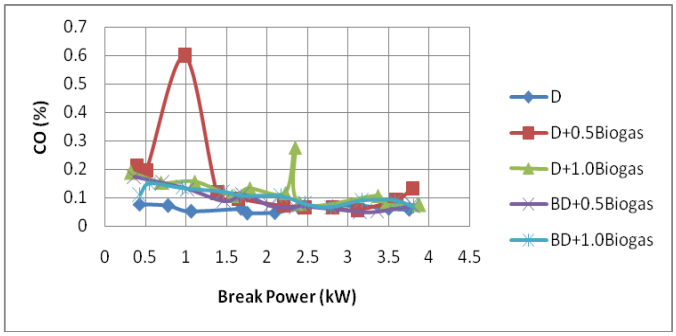

Fig 9: Variation of CO with Break power

Carbon dioxide (CO_2) emissions

The variation of CO_2 emission of the engine with brake power is show in fig 10 was operated on diesel and dual fuel mode. Figure shows the biogas flow rate of 1.0m3/hr shows a reduced level of CO2 emissions. However, under this mode, the performance of engine was noisy, harsh, and intermittent. For other flow rates of biogas, the CO_2 level is higher in the emissions. This is because the biogas contains CO_2, and the same is found in the emissions also.

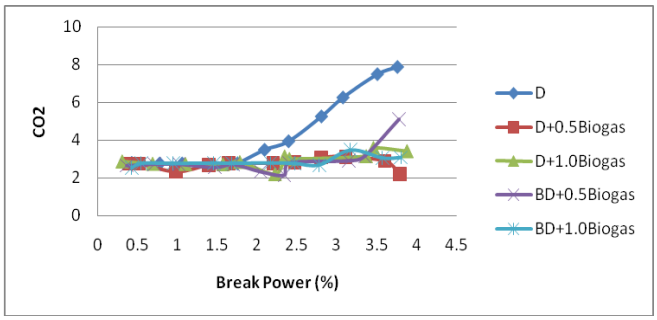

Fig 10: Variation of CO_2 with Break power

3. CONCLUSIONS

The objective of this work was to study the performance of a single cylinder diesel engine when operated in biogas diesel dual fuel mode. It was studied by observing different parameters of diesel engine, following pars reports the short pres conclusions of this work. It was found that the engine when operated on biogas-diesel and biogas-biodiesel dual fuel mode develops nearly same power as that of when operated on neat diesel mode. Near full load condition, the brake power developed in dual fuel mode is same as that of developed by neat diesel operation. Mechanical efficiency the engine was also tested. It was noted that the biogas-diesel and biogas-biodiesel dual fuel mode has same as the mechanical efficiency over neat diesel mode. This trend is similar for part load as well as full load operation. Volumetric efficiency of the engine was found decreasing

with increasing loads. It further decreased in fuel mode as biogas is introduced into the induction manifold direct and is replacing some amount of air being sucked. Thermal efficiency of engine was higher in diesel dual fuel mode as compared to neat diesel mode. This is due to the methane from biogas, which has good combustion characteristics. Biogas forms a homogeneous mixture before entering the combustion chamber. This is helpful for achieving near complete combustion of the charge. This is major advantage of this system.

REFERENCES

[1] Pisarn Sombatwong, Prachasanti Thaiyasuit and Kulachate Pianthong "Effect of Pilot Fuel Quantity on the Performance and Emission of a Dual Producer Gas Diesel Engine". Energy Procedia 34 (2013) 218 – 227

[2] Mohd Hafizil Mat Yasina, Rizalman Mamata, Ahmad Fitri Yusopa, Daing Mohamad Nafiz Daing Idrisa, Talal Yusafb, Muhammad Rasulc, Gholamhassan Najafid "Study of a diesel engine performance with exhaust gas recirculation (EGR) system fuelled with palm biodiesel". Energy Procedia 110 (2017) 26

[3] Saket Verma , L.M. Das, S.C. Kaushik "Effects of varying composition of biogas on performance and emission characteristics of compression ignition engine using exergy analysis". Energy Conversion and Management 138 (2017) 346–359

[4] Bhaskor J. Bora , Ujjwal K. Saha , Soumya Chatterjee , Vijay Veer "Effect of compression ratio on performance, combustion and emission characteristics of a dual fuel diesel engine run on raw biogas" Energy Conversion and Management 87 (2014) 1000–1009

[5] Youngjin kim , Nobuyuki Kawahara, Kazuya Tsuboi, Eiji Tomit, "Combustion characteristics and NOX emissions of biogas fuels with various CO2 contents in a micro co-generation spark-ignition engine"applied energy 182(2016)539-547

[6] Guven Gonca , Erinc Dobrucali , "Theoretical and experimental study on the performance of a diesel engine fueled with diesel biodiesel blends.",renewable energy 93(2016)658-666

[7] Bhaskor J. Bora, Ujjwal K. Saha, "Experimental evaluation of a rice bran biodiesel ebiogas run dual fueldiesel engine at varying compression ratios.", renewable energy 87(2016)782-790

[8] J. Li, W.M. Yang,H.An, D. Zhao,"Effects of fuel ratio and injection timing on gasoline/biodiesel fueled RCCI engine: A modeling study." applied energy155(2015)59-67

[9] Cenk Sayin, Metin Gumus , "Impact of compression ratio and injection parameters on the performance and emissions of a DI diesel engine fueled with biodiesel-blended diesel fuel.", applied energy 31(2011)382-3188

[10] Bhaskor J. Bora,Ujjwal K. Saha, "Optimisation of injection timing and compression ratio of a raw biogas powered dual fuel diesel engine." applied energy 92(2016)111-121

[11] Kyunghyun Ryu , "Effects of pilot injection timing on the combustion and emissions characteristics in a diesel engine using biodiesel–CNG dual fuel." applied energy 111(2013)721-730

[12] Mohammed EL_Kassaby, Medhat A.Nemit_allah,"Studying the effect of compression ratio on an engine fueled with waste oil produced biodiesel/diesel fuel ."Alexandria engineering journal (2013)52,1-11.