Experimental Studies of Utilization of Biogas with Biodiesel in Diesel Engine Generator for Electricity Generation

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Abstract— *With the rising population worldwide, energy consumption has been increased in the last few decades. To fulfill this energy consumption demand more inclination is towards conventional coal or thermal sources of energy generation. With their continuous use they will not be available in future for long time. In order to meet this increasing energy demand and supply of fuel, renewable energy sources are found to be the best alternatives. The biogas is one of the sources of renewable energy, consisting of approximately 55-60 % of methane which can be burned to produce heat and electricity, and many other operations using an internal combustion engine, for the conversion of biogas into both electricity and heat. The harmful emissions from burning of methane are reduced and keep the environment clean. In this paper performance and emission characteristics of IC engine using blends of rice bran oil and its bio-diesel with biogas as fuel in normal mode of operation under different engine test conditions are studied and discussed.*

Keywords— Biogas, Biodiesel, Electrical power, Rice bran oil.

I. INTRODUCTION

Electricity is the most important form of energy and it plays a significant role in economical growth of any developing country. Since decades increase in global dependence on fossil fuels has led to the release of CO_2 into the atmosphere. To reduce the affect of GHG, alternative fuels are the best option to use for transportation and power generation applications. In the present scenario, use of biomass-derived biogas is more promising fuel for rural electrical power generation and is addressing technique for controlling emissions levels. Biogas consists of mainly 55-60 % of methane which can be burned to produce heat and electricity, and many other operations using an internal combustion engine, for the conversion of biogas into both electricity and heat [1]. Methane and electric power formed in anaerobic digestion facilities may be used to replace energy derived from fossil fuels, thereby reducing emissions of greenhouse gases, since the carbon in biodegradable material is a component of a carbon cycle[2]. Producing the renewable energy in decentralized mode is one of the ways to fulfill the rural and small scale energy needs in a reliable, affordable and environmentally sustainable way [3].Biogas is best suited for developing decentralized power plants to fulfill the energy needs of rural and remote areas. Biodiesels obtained from vegetable oils present an alternative to diesel oil since biodiesels have many advantages when compared to fossil fuels. Biofuels as a source of fuel are capable of reducing the consumption of fossil fuels and pollution caused by them; therefore to reduce the affect of GHG emissions and to fulfill the energy demands these can be the best alternative fuels [4]. Use of biofuels such as liquid fuels (oil methyl ester) and gaseous fuel (biogas) in an internal combustion (IC) engine for various applications proves more promising. Excess electricity may be sold to suppliers or place into the native grid. The amount of inorganic matter not converted into biogas is called digestate and is economical and slurry which can be used as organic manure as an agricultural fertilizer [5].

II. METHOD OF STUDY

In this experiment rice bran oil methyl ester and biogas are selected for study. The reason for this is because these two fuels are readily available in India and are cost effective. Different experiments are carried out to find the physical and chemical characteristics of the oil, transesterified and blended form. A single cylinder diesel engine has been considered for the present research as it has great future potential for use in agriculture and small power generating units. The performance and emission study of this engine using blends of rice bran oil and its bio-diesel with biogas as fuel in normal mode of operation under different engine test conditions are studied. The test conditions are at optimum gas flow rate and variable load and variable gas flow rates at optimum load.

III. EXPERIMENT SETUP

A simple internal combustion engine can be used to convert it into dual fuel diesel engine by connecting a gas mixer at its inlet manifold. Further, a fuel control mechanism needs to be installed to limit the supply of liquid fuel. The power output of the engine was normally controlled by varying the flow of quantity of biogas. A four stroke, single cylinder air cooled diesel engine is employed for the present study. Five gas analyzer were used to measure the concentration of gaseous emissions such as, unburned hydrocarbon, carbon dioxide and oxygen level. The performance and emission tests are carried out on the C.I. engine using biogas and various blends of diesel-biodiesel blends as fuels. The experiment was carried out in CI engine at constant speed of 1500rpm. The test was conducted by varying the load to evaluate comparatively of performance characteristics of CI engine using diesel and biogas for various load conditions as 20%, 40%, 60%, 80% and 100% respectively. Moreover, time for fuel consumption by the engine was also noted to calculate specific fuel consumption under various load conditions. With respect to different load conditions, volume of biogas was varied over wide range. The brake thermal efficiency, brake specific fuel consumption, brake power, brake energy consumption were calculated. The five KW load bank was used in setup. A biogas flow meter is used to calculate the flow of biogas. It gives the direct reading of biogas volume in m^3/hr.

Fig.1 Photograph of experimental set up

Key: 1. Engine. 2. Dynamo. 3. Resistive load bank. 4. Electric control panel. 5. Air surge tank. 6. Biogas flow meter. 7. Digital tachometer. 8. Exhaust gas temp thermocouple. 9. AVL exhaust gas analyser. 10. Probe. 11. Fuel measuring burette. 12. U-tube manometer

TABLE 1
ENGINE SPECIFICATIONS

Parameters	Specifications
Engine	Fc Dod
Stroke Length	110mm
No Of Strokes	4
Cylinder Diameter	102mm
No Of Cylinder	1
Cooling Media	Air Cooled
Rated Capacity	6kw
Fuel	Diesel

IV. RESULTS AND DISCUSSION

The performance and emission tests are carried out on the dual fuel mode C.I. engine using various blends of diesel-biodiesel blends as pilot fuel and biogas as primary fuel. The performance of the engine is evaluated in terms of, brake power, brake specific fuel consumption, brake thermal efficiency. Emission of the engine is analyzed (HC, CO, CO_2).

4.1 Performance Analysis

The engine performance parameters and exhaust gas emission characteristics of dual fuel engine in which primary fuel is biogas at fixed flow rate(3kg/hr) and blends of B20, B40, B60 of rice bran biodiesel used as a pilot fuel compared with diesel.

4.1.1 Brake power (BP)

The brake power (BP) as a function of load obtained during engine operation dual fuel engine in which primary fuel is biogas and blends of B20, B40, B60 of rice bran biodiesel used as a pilot fuel compared with diesel has been shown in figure 2.

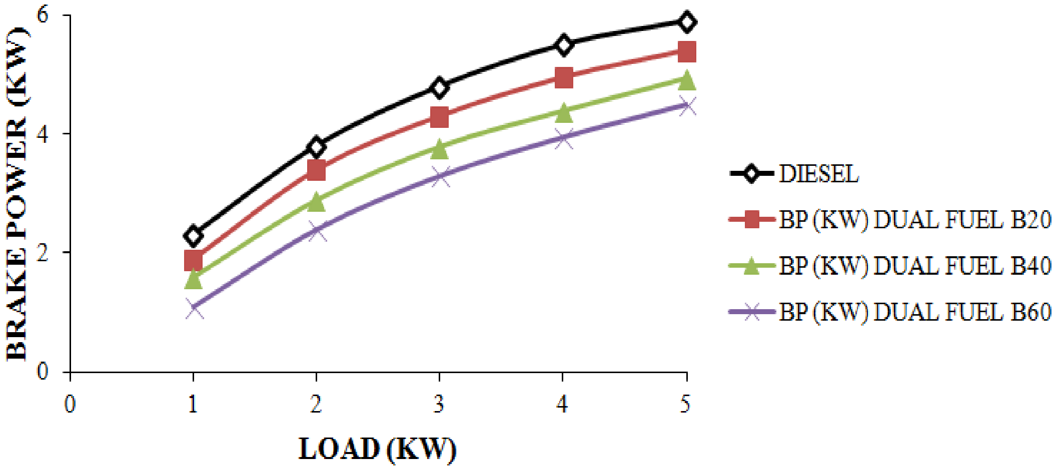

Fig. 2 Variation in brake power with change in load

Brake power of the engine increases with increase in the load on the engine. The brake power of the diesel at all load conditions is more than the dual fuel mode. Dual fuel B20 and B40 is more than Dual fuelB60 as shown in figure 2.

4.1.2 Liquid Brake Specific Fuel Consumption

Figure of the liquid brake specific fuel consumption as a function of load obtained during engine operation dual fuel engine in which primary fuel is biogas at fixed flow rate and blends of B20, B40, B60 of rice bran biodiesel used as a pilot fuel compared with diesel have been shown in figure 3.

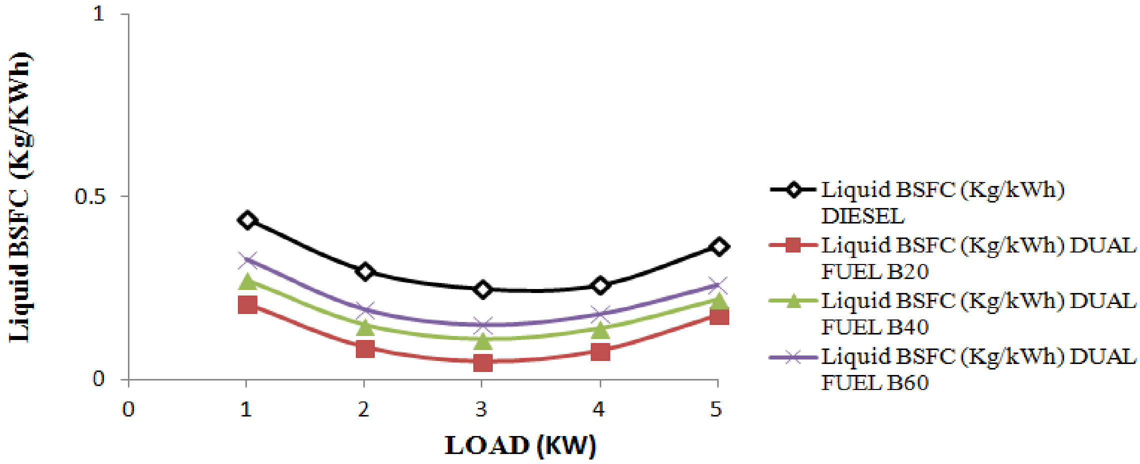

Fig. 3 Variations in Liquid brake specific fuel consumption with change in load.

Liquid BSFC is defined as the amount of fuel consumed for each unit of brake power per hour. Figure shows that liquid BSFC in case of diesel is more than the dual fuel mode. Dual fuel in which pilot fuel is B20 has lesser liquid BSFC than B40 and B60.

4.1.3 Brake thermal efficiency

Figure of the brake thermal efficiency as a function of load obtained during engine operation dual fuel engine in which primary fuel is biogas and blends of B20, B40, B60 of rice bran biodiesel used as a pilot fuel compared with diesel has been shown in figure 4

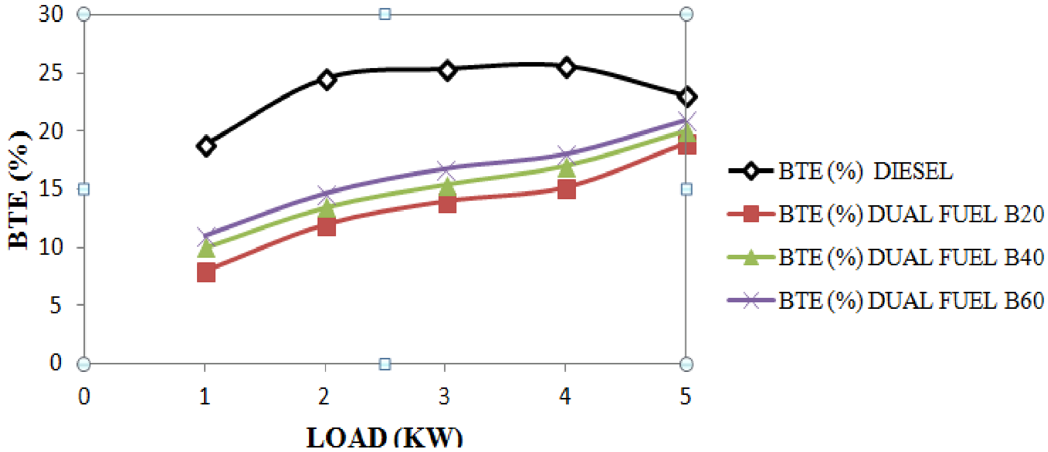

Fig. 4 Variation in Brake thermal efficiency with change in load

In all cases of dual fuels in which pilot fuel is biodiesel, brake thermal efficiency increases with an increase in load. This can be attributed to reduction in heat loss and increase in power with increase in load. It is also observed that diesel exhibits slightly higher thermal efficiency at most of the loads than Rice bran oil methyl ester and its blends. The factors like lower heating values and higher viscosity of the ester may affect the mixture formation process and hence results in slow combustion hence reducing the brake thermal efficiency. The molecules of bio-diesel (i.e. methyl ester of the oil) contain some amount of oxygen, which takes part in the combustion process. Diesel has higher calorific value than biogas. So more is brake thermal efficiency than dual fuel.

4.2 Emission Analysis

4.2.1 HC Emissions

The variation of hydrocarbon with respect to load for different blends of dual fuel B20, dual fuel B40, and dual fuel B60 is shown in figure 5.

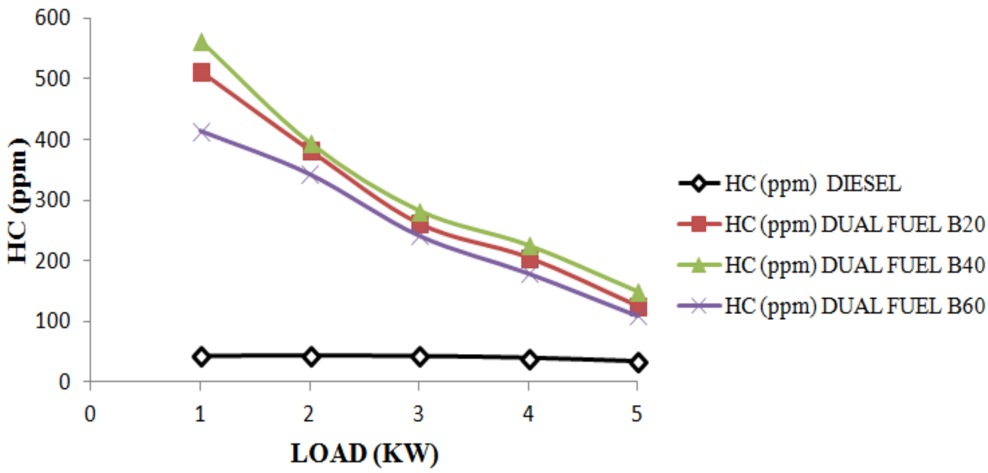

Fig. 5 Variations in HC with change in load

Figure 5 shows that unburned hydrocarbons in dual mode are more as compared to diesel. This is due to diesel is lean than biogas-biodiesel mixture. This higher HC emission is due to the incomplete combustion of the fuel. The biogas induction through the intake manifold reduces the volume of inducted air; hence, the combustion takes place with less oxygen resulting in higher HC emission [27]. In the figure 4.7 shows that B60 has lesser HC than B20, and B40.

4.2.2 CO Emissions

The variation of carbon monoxide with respect to load for different blends of dual fuel B20, dual fuel B40, and dual fuel B60 is shown in figure 6

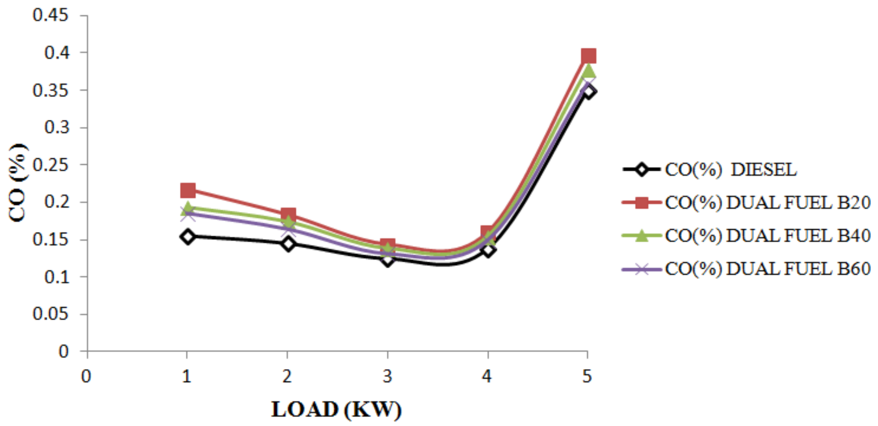

Fig. 6 Variations in CO with change in load

Carbon monoxide (CO) in diesel engines is formed during the intermediate combustion stages. Carbon monoxide decreases with increase in Rice bran oil methyl ester and biogas in fuel. Figure shows that on lower load the CO emissions of diesel are less than biogas. At the full load conditions dual fuel B20 has higher CO emission than dual fuel B40 and dual fuel B60 blends.

4.2.3 CO_2 Emissions

The variation of carbon dioxide with respect to load for different blends of dual fuel B20, dual fuel B40, and dual fuel B60 is shown in figure 7.

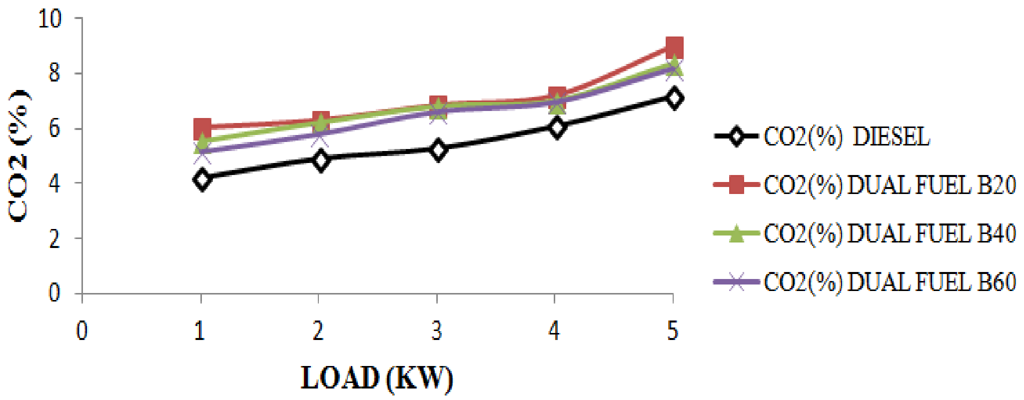

Fig. 7 Variations in CO_2 with change in load

Figure shows CO_2 emissions of diesel are less on lower load than dual fuel. On the full load CO_2 emissions of diesel are more than that of dual fuel. Among of the dual fuel blends B60 has lower CO_2 than other blends dual fuel B40 and dual fuel B20.

V. CONCLUSIONS

From this experiment, it has been concluded that biogas is a renewable fuel, which can be used in dual-fuel mode in the diesel engine without any changes to an IC engine for power generation at remote areas. When compared at equal power output situation, the dual fuel engine (biodiesel-Biogas) performance is better than neat diesel. In this set up, diesel engine performance were experimentally investigated and the following conclusions may be drawn:

1) The use of biogas and biodiesel in dual fuel mode in diesel engines has not only reduced the consumption of diesel but also protect environment and human health.

2) The CO_2 emission in the dual fuel mode has been reduced when compared to neat diesel.

3) Carbon monoxide decreases with increase in Rice bran oil methyl ester and biogas in fuel.

4) The dual fuel mode with biogas flow rate of 3kg/hr for various load has been experimentally performed and studied in detail

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