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Advance Biogas System for Irrigation - A Typical Application

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***Abstract:*-- Anaerobic reaction of the organic substances like vegetable/food waste, animal/human waste and agricultural waste produces gas called as Biogas. This gas chemically consist of CH4, CO2 as major content(50-75% & 30-40%) and other constituents such as N, H2S, H , O2 and H2O vapour in small amount (about 10% all). It is well known fact that CH4 is a good IC engine fuel. As the gas mix with air easily it can be used as fuel in compression ignition (CI) engines. CO2 content from it can be either reduced or completely removed by simple water scrubbing process. The burning of this gas gives clean energy with low emission. If it is used in compressed form in cylinders, it can be a supplement to compressed natural gas (CNG) and liquefied petroleum gas (LPG) and. Present study has demonstrated a small capacity biogas plant which is constructed using kitchen waste as feed stock. The gas produced from it is supplied to computerized CI engine test rig of 3.5 KW. Various tests were carried out at different speeds and load conditions. Typical running conditions are demonstrated with 2300 rpm and 20 N-m. The system works fairly well at low load conditions.**

***Key words:*- Kitchen waste, biogas, scrubbing process, alternative fuel.**

NOMENCLATURE	
BSFC	Brake Specific Fuel Consumption in g /kwh
m_f	Mass of fuel consumed in kg /s
BP	Brake power in kw
N	Speed of engine, rpm
T	Torque produced by engine, N-m
IP	Indicated Power, kw
n	Number of cylinders in engine
p_{mi}	Mean effective pressure, N/m^2
A	Area of single cylinder, m^2
L	Stroke length of engine, m
K	Constant 0.5 for 4S engine

I. INTRODUCTION

The major issue of any country is depletion of fossil fuels. As people throughout the world are relying on these fuels, they are near to exhaust. So it becomes a global issue to develop economical and feasible renewable resources. The renewable energy resources like solar energy, wind energy, bio diesel, biogas from biomass are some of the alternative to fossils fuel [1].

Out of these, biogas has lot of scope and has prospective future in India. As most of the population is in middle class and they are very sensitive to the price hike of fuels and LPG [2]. In the early 1980's on large scale in rural areas biogas plants were constructed in India. Government of India had also contributed in by offering the subsidies. But based on survey nowadays most of the plants are not in working condition. Survey results have led to the following conclusions that could be the reasons for the shutdown of plants:

1) Due to civilization and unpredictable monsoon people are leaving villages and coming to the city for jobs resulting in decreasing cattle production hence reduced amount of cow dung. (Conventional biogas plant requires 40 kg of cow dung/day/m3, and most of the plants are constructed for minimum 3 m3 and above capacity)

2) Due to leakages in floating type domes or cracks in fixed type domes, gas leaks and due to which people think that these plants do not work [3][4]. This calls for

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modifying existing biogas plant which is suitable for rural as well as urban areas. These advance biogas plant are made up of fibre water tank. It requires kitchen waste as a feed stocks so it can be used every where its position can be changed so it can be installed anywhere like terrace, balcony or on the ground. This gas is alternative for LPG so large scale production of this renewable energy could save huge amount of fossils fuels as well as money. With few modifications, biogas can be used for running diesel engines to generate electricity [5]. Also this CI engine can be directly coupled to the water pump used for irrigation. This system overcomes the problem of load shedding in villages for irrigation. Some researchers have tried to build it by using two fibre water tanks. But the present study has designed a biogas plant with only one water tank. This reduces the cost of manufacturing by 40 percent. The lowest cost and maintenance free working increases the demands of such biogas plants for irrigation purposes in villages.

Biogas is a mixture of gases like methane and carbon dioxide. It is produced by a certain kinds of microorganisms,when air or oxygen is absent. ("anaerobic conditions."are due to absence of oxygen). Animals that eat a lot of plant material produce large quantity of biogas. The biogas is produced by numerous microorganisms living in its digestive system of animals like cows or elephants. Decaying organic matter builds up under wet conditions especially at the bottom of the lakes leading to biogas [6].

Time and again people have been using biogas. Biogas was used for streetlights (gaslights) by the underground pipes even before electricity was used. World wide , biogas is used to cook , fuel buses and light homes. It was collected from large-scale sources and through small domestic systems in many villages. But these days it is crucial to keep a commercial approach towards the biogas for production and its consumption [7].

1.1 Comparison With Conventional Biogas Plants

In the anaerobic digestion, organic waste (feedstock) is fed to a tank called as digester where microorganisms break down the waste material and discharge biogas. Biogas consists of mainly methane and carbon dioxide. The slurry coming out of the plant is also used as an organic compost [8]. The recent trend of using low calorie inputs like municipal organic waste, manure, distillery seweage, makes methane generation in the biogas plants highly unproductive. The methane gas production efficiency of the plant can be improved by using the organic waste having high calorific and nutritive values. In this way by using simple principles it brings in many more benefits over the conventional systems, also it reduces the size and cost of the new compact system. The new biogas system is very compact and handy, whereas the conventional biogas system (Din Bandhu model) occupies about 3-4 cubic meters land space[9]. It is an economical and feasbile system as it requires only a few kilograms of organic waste and the disposal of merely 5 liters of effluent slurry per day [10] [11].

In the present study biogas from the plant is directly used in the four stroke single cylinder diesel engine of 5 HP capacities with little modification done on the test rig. In the intake manifold biogas is supplied with the air. The testing is done on a computer control IC Engine of the automobile engineering lab, SVERI's College of engineering Pandharpur, Maharashtra, India.

II. MATERIAL AND METHODS

This study emphasis on testing the developed biogas plant and characteristics studied of the biogas plant. A small capacity biogas plant is prepared by using features of Arti biogas plant as shown in the fig1. The sample of the biogas is collected from the plant and analyze on the gas chromatography for finding the chemical composition. Tests are carried on seven samples collected from the biogas plant with different feed stock used. The feed stock like, waste rice from kitchen, waste bananas, mix vegetables etc. was used.

Table 1. Typical range of composition of biogas for all samples

Matter	Percentage (%)
Methane (CH_4)	50-75
Carbon dioxide (CO_2)	25-50
Nitrogen N_2	0-10
Hydrogen H_2	0-1
Hydrogen Sulphide H_2S	0-0.3
Oxygen O_2	0-2

Specifications Of Test Rig Are As Follows:

Engine : Single cylinder Diesel engine
Capacity : 5H.P. (3.5KW@2200rpm)
Make : Comet make (CPW-5)
Cooling : Water cooled

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Swept Volume : 345cc

The other characteristics of this test rig are a computer controlled engine which monitors the run time situations more accurately than human observations so it reduces errors in the measurements. Also it gives the pressure versus crank angle graph which is very important for the present study [12].

Figure 1. Biogas Plant

Figure 2. Modification to Diesel Engine

III. TESTING AND RESULTS

Tests carried out on computer control diesel engine and following results are obtained.

3.1.1 Brake Specific Fuel Consumption Vs Brake Power

Various graphs are plotted to check the characteristics of the biogas when it is used as an alternate fuel. Brake specific fuel consumption is the criteria of economical power production of the engine.

Theoretically it is expressed as,

$$BSFC = \frac{m_f}{B.P.} \quad kg/kwh \qquad (1)$$

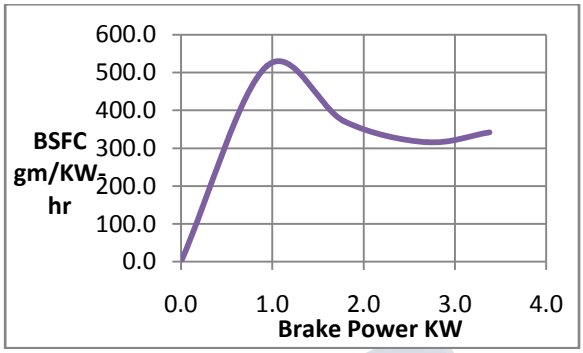

Figure 3. BSFC Vs BP

Figure 3 shows graph between brake specific fuel consumption and brake power. It is found that the BSFC is more which is around 500g/kwh at low B.P. and it gradually decrease up to 2-3kw again it increased marginally as B.P. increases.

3.1.2 Mechanical efficiency Vs Brake power

The actual and theoretical power output of the engine is calculated by the equations,

$$BP = \frac{2\pi NT}{60*1000} \quad kw \qquad (2)$$

$$IP = \frac{np_{mi}\,ALNK*10}{6} \quad kw \qquad (3)$$

And the ratio of actual to theoretical power output is termed as mechanical efficiency of the engine. Figure 4 shows Mechanical efficiency increases linearly with respect to B.P. up to certain limit (upto ~2KW B.P.) and then there is no change in efficiency though B.P. increases It is observed that maximum mechanical efficiency is 75%.

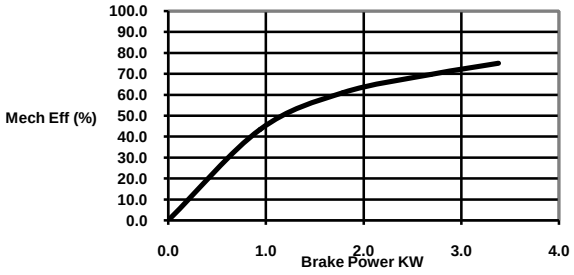

Figure 4. Mechanical Efficiency versus BP

3.1.3 Pressure Versus Crank Angle For A Sample Load

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Figure 5 gives the idea about the pressure rise in the cylinder through the angle of rotation. This is plotted between cylinder pressure and crank angle graph for one sample load of 20 N-m. It is observed that there is slight variation in the pressure rise of the cylinder near about 15 degrees after TDC. This is because the ignition delay of biogas is more.

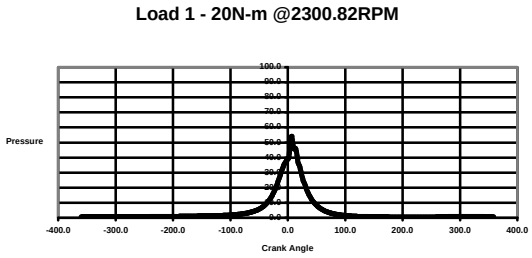

Figure 5. Pressure versus Crank Angle for a sample load

3.1.4 Pressure Versus Volume For Sample Load

The curve is similar to the PV diagram of actual diesel cycle PV graph for sample load (fig.6). It indicates that bio gas gives the same pressure rise in combustion chamber.

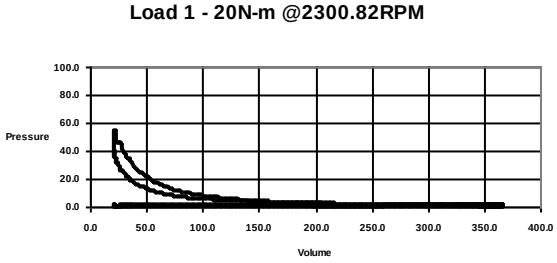

Figure 6. Pressure Vs Volume

3.1.5 Pressure Versus Crank Angle For All Loads

Figure7 shows the graph for all the selected loads and is plotted for the pressure versus crank angle. It is clear that there is slight variation in the all lines with various load conditions.

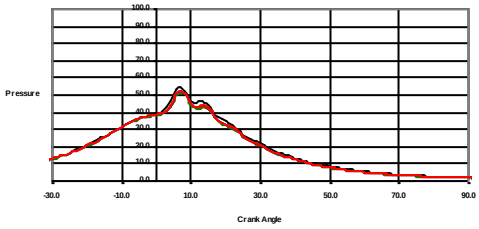

Figure 7. Pressure versus crank angle

This makes biogas very much suitable as an alternative, renewable, cheapest fuel for diesel engine.

3.2 Application For Irrigation Purpose

From the characteristics study of the biogas on test rig, it is clear that CI engine runs efficiently. The irrigation pump is coupled directly to the engine with synthetic material (to absorb the shock or sudden load condition). The engine requires some strong foundation while fixing it in field. The biogas plant is installed near to the engine. The capacity of the biogas plant is 2000liters which runs the 5 HP CI engine near about two and half hours. So probably this system is one of the best alternatives to overcome the load shedding problem as well as a good renewable source for the middle class farmers.

IV. CONCLUSIONS

Based on the results it can be concluded that the biogas is a renewable source of energy which can be an alternative to fossil fuel. It runs the CI engine very efficiently with minor modifications to engine. This alternative is a cost effective to run a CI engine on biogas energy. It is safe and affordable source of energy (nearly Rs10000 require to install the plant of 1500 lit capacity). Feed stock material is available in ample quantity in rural areas. The CI engine's inlet manifold is only modified to use dual fuel so in absence of the biogas the engine can run purely on diesel so giving uninterrupted source of energy. Thus this is an economical alternative to fossil fuel and can save nations sources of non renewable energy source.

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