A REVIEW ON PRODUCTION AND APPLICATION OF BIOGAS AS A FUEL FOR DIESEL ENGINE

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ABSTRACT

Biogas is derived from digestion of organic matters, is considered as good alternative source for blending / replacement of diesel fuels, because of its good mixing property with air. The gas production can be done by anaerobic digestion of various organic matters in the absence of oxygen, which offers low cost and less emission than petroleum fuels. This study reviews that production of biogas and up gradation through purification, storage method and its application which was earlier concluded by various researchers. This literature specifically considered for biogas in diesel engine and engine modification, its emission characteristics.

Keywords: *Bio-Gas, C I engine, anaerobic digestion, liquid biomethane (LBM).*

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1. INTRODUCTION

India has largest population in the world, in order to full fill the energy needs of the country which is mainly depending on fossil fuels but the petroleum source is depleting all over the world. even though energy is the primary requirement for development of any country. The most energy consumption sectors are industries, transport, domestic, agriculture needs. The growing population demanding large amount of energy consumption in all sectors. This increased consumption of energy has also resulted in the country to depend more on fossil fuels. From day the world's started using the fossil fuel it is understood that the main energy source will be ended within next few more years and also continuous use of fossil fuels causes environmental problems. This depleting nature of fossil fuel and increasing demand resulting gradually increase in the price of oil and gas. Gradual increase of price directly or indirectly affects on economic stability of the country and common man life style. India imports 70% of petroleum products from outside the country by spending more on foreign exchange. The increase of population rising fuel cost gradually compare to last few decade. To overcome this increasing energy demand and also to reduce the harmful emissions by fossil fuel the best way identified by many researchers was optimum dependency on exhaustible fuels and look for utilization of non-exhaustible resources, hence the scientists are looking for non-renewable energy

sources like biogas is one of the promising source as it contains methane in its natural form. In India .many programmes have been implemented by the ministry of Non- Conventional Energy Sources for proper use of various renewable energy sources in the country. As a result, the effort made by researchers and scientists during the past twenty five years, various technologies have been developed. This includes biogas plants, solar water heaters, improved wood stoves, solar cookers etc., among the above mentioned technologies biogas production is most suitable and promising technique for India in future [1].

India is breeding with large cattle population with similar propionate of human beings which gives abundance of raw material for producing biogas. With this municipal sewage can be used for this purpose. One of the alternate sources 'Sulabh' propagates the biogas plant that utilizes human excreta as a raw input substance. In the past 35 years, the programme propagates into thousands of such plants throughout India. Biogas replaces fossil fuels and the methane contained in it is natural form. The methane is collected and utilized commonly for production of electricity as well as for domestic purpose. Recent life cycle assessment studies have demonstrated that the methane gas is one of the most energy efficient and ecofriendly sustainable vehicle fuels. The country occupies second position in the world for biogas production and fifth in wind energy and photovoltaic power generation. Renewable energy contributes to about 7-9% of the total power generating capacity in the country at present.

The origin of biogas is traced back to the Persians and also, They discovered that organic matter such as rotten vegetables gave a flammable gas that could be used for combustion purposes. Marco Polo has mentioned the use of a gas generated from covered sewage tanks in China. This was believed as early as 2,000– 3,000 years ago in ancient China. In modern times in India, the first sewage plant was built in Bombay in 1859; an idea that was brought to the UK in 1895, when produced wood gas from wood and later coal was used to light street lamps. The use of biogas in internal combustion engines dated back to Second World War when thousands of vehicles were ran by sewage gas in Europe. "In 1942-44, garbage collection trucks with diesel engines were operated using purified and compressed sewage gas in Zurich, Switzerland. "Around 1955 the importance of biogas was significantly reduced, as biogas was not profitable any longer due to excess cost of production compared to fossil fuels.[2].

2. BIOGAS PRODUCTIONS

Biogas is produced from biodegradable matter in closed container called digester. The biogas is generated purely by anaerobic digestion and also called as bio gasification. Anaerobic digestion is naturally occurring chemical process strictly by anaerobes, which converts organic matter to methane and carbon dioxide. Anaerobic digestion occurs in three stages (discussed in 2.1, 2.2, and 2.3.). The chemical reaction takes place in the presence of methano genetic Bactria with water in the absence of

oxygen. Usually there should be no oxygen molecule within the digester as it leads to formation of water, not methane and also the oxygen reduces the calorific value of biogas.

2.1 **Hydrolysis:** This is the first step where particulate materials get converted to soluble compounds such as polysaccharides are converted into monosaccharide. Proteins are split into peptides and amino acids suitable for further breakdown in the next step[3][4].

2.2 **Acidification:** this is the second stage in which Acid-producing bacteria, convert the intermediates into acetic acid (CH_3COOH), hydrogen (H_2) and carbon dioxide (CO_2). These bacteria are strictly anaerobes and can grow under acid conditions. To produce acetic acid, they need oxygen and carbon. For this, they use the oxygen solved in the solution or bounded-oxygen. Hereby, the acid-producing bacteria create an anaerobic condition which is essential for the methane producing microorganisms. Moreover, they reduce the compounds with a low molecular weight into alcohols, organic acids, aminoacids, carbon dioxide, hydrogen sulphide and traces of methane.

2.3 **Methanogenesis:** The third and final step of anaerobic degradation is known as methanogenesis. In this, process one group of microorganism known as aceticlastic methanogens which converts acetic acid into H_2 and CO_2. Then a second group of microorganism referred as Hydrogen-utilizing methanogens combined H_2 and CO_2 into methane (CH_4). The end product of methanogenesis is biogas, a mixture of methane and carbon dioxide.[5][6]

3. COMPOSITION OF BIOGAS

Biogas is a low density gaseous fuel whose major constituents are methane and carbon dioxide, traces of water vapor and other impurities. The content of CH_4 gas depends on various as illustrated

Table - 1: Source [7]

Biogas Composition	Fluctuation range	Average
Methane	45- 70%	60%
Carbon dioxide	25-55%	35%
Water vapor	0-10%	3-10%
Nitrogen	0.01- 5%	1%
Oxygen	0.01-2%	0.30%
Hydrogen	0-1%	<1%
Ammonia	0.01-2.5 mg/m^3	0.7 mg/m^3
Hydrogen sulfide (raw measurement)	10-30000 mg/m^3	<500 mg/m^3
Hydrogen sulfide (pure measurement)	10-30000 mg/m^3	<50 mg/m^3

4. FACTORS AFFECTING ON BIOGAS PRODUCTION

4.1 Biogas production are influenced

Anaerobic digestion will occur best within a pH range is 6.8 to 8.0. More acidic or basic mixtures will ferment at a lower speed. The introduction of raw material will often lower the pH (make the mixture more acidic). Digestion will stop or slow dramatically until the bacteria have absorbed the acids. A high pH will encourage the production of acidic carbon dioxide to neutralize the mixture again.

4.2 Temperature

Anaerobic breakdown of waste occurs at temperatures between 0°C and 69°C, but the action of the digesting bacteria will decrease sharply below 16°C. Production of gas is most rapid between 25°C and 35°C. This is due to the fact that two different types of bacteria multiply best in these two different ranges, but the high temperature bacteria are much more sensitive to ambient influences. A temperature between 32°C and 35°C has proven most efficient for stable and continuous production of methane (4). Biogas produced outside this range will have a higher percentage of carbon dioxide and other gases than within this range.

The effect of temperature on fermentation is actually on the kinetics of the digester reactions, i.e. the rate at which raw materials are digested. The experiments on this subject shown that the quantity of gas generation is about the same regardless of the temperature in the range 15-35°C for the quantity of feed. But, if the temperature is higher, the action of the bacteria speeds up and the time for digestion is shortened. When the temperature drops, the reverse case is observed, so that fermentation time extends.

4.3 Retention time

Retention time (also known as detention time) is the average period that a given quantity of feed remains in the digester to be acted upon by the methanogens. A digester should have a volume of 50 to 60 times the slurry added daily. The retention time is also dependent on the temperature and up to 35 degrees C, the higher the temperature, the lower the retention time. Maximum and minimum time required.

4.4 Toxicity

The Minerals like iron, heavy metals and the detergents are some of the toxic materials that inhibit the normal growth of pathogens in the digester. a Small quantity of mineral ions (e.g. sodium, potassium, calcium, magnesium, ammonium and sulphur) also stimulates the growth of bacteria, while very heavy concentration of these ions will have toxic effect. Similarly, heavy metals such as

copper, nickel, chromium, zinc, lead, etc. in small quantities are essential for the growth of bacteria but their higher concentration has toxic effects.[8]

5 Biogas Purification

Biogas consists so many impurities such has carbon dioxide is the one major impurity which reduces the burning capacity and also hydrogen sulphide, traces of moisture, nitrogen etc. this impurities are removed through various techniques such as[9][10].

5.1 Removal of H_2S

The gas coming out of system is heated to 150^0 and over ZnO bed, maintained at 180^0 C leaving process gas free of H_2S.

$$ZnO + H_2S = ZnS + H_2O.$$

$$ZnSO_4 + 2NaOH = Zn(OH)_2 + Na_2SO_4$$

5.2 Removal of CO_2

CO_2 is high corrosive when wet and it has no combustion value so its removal is essential to improve the quality of biogas.

The processes to remove CO_2 are as follows –

a) Caustic solution, NAOH – 40%

$$NAOH + CO_2 = NAHCO_3$$

b) Renfield process – K_2CO_3 - 30 %

6. BIOGAS STORAGE

Biogas has low density, whose density is lesser than air so it occupies more space compare to other gaseous fuels which has toxic gasses, present in it is harmful to metallic storage devices. The pressure required is 70-80 bar and temperature of -80°C, to change biogas from gaseous to liquid state so that biogas are stored in three different storage condition.

6.1 low pressure storage

These storage system are less expensive in which floating drums gas holders form low pressure storage option. the gas holder can be made of poly vinyl chloride(PVC),fibroglass ,steel. The

PVC gas holder are trouble free and does not react with H_2S, The pressure maintained by floating gas holders are approximately 0.135bar. [11]

6.2 Medium pressure storage

Biogas can be stored at moderate pressure of 0.137-14bar. This can be achieved by compressing the gas with compressor. Biogas can be stored in LPG tanks at 18bar pressure; energy needed for compression is about 10% of energy content of the stored gas.[12][11]

6.3 High pressure storage

After purification biogas can be stored as a compressed biomethane (CBM). At high pressure removal of H_2S and water vapor are essential because these impurities likely to condense and causes corrosion. The cost of biogas compressing to high pressure much greater than the cost of compressing it to medium pressure, because of this biogas is upgrade to biomethane. The energy needed for compression of biomethane is approximately 17% of energy content of the gas.[11]

6.4 Biogas Diesel Engine Application

Biogas can be used in diesel engines under dual-fuel mode because it has high self-ignition temperature. The meet requirement dual-fuel is a diesel engine is modified in which biogas is inducted with air into engine cylinder. The mixture of fuel and air does not auto ignite itself , so a small amount of diesel usually called pilot fuel is injected for promoting combustion. The gas should homogeneously mixed with air , that leads to very low level of smoke[13].a wide Varity of primary and pilot fuels can used in dual-fuel engine but the pilot fuel should have high cetene quality. Biogas can also be used as fuel in dual-fuel engine with vegetable oil as pilot fuel. The performance of engine depends on quantity of biogas and pilot fuel used. The significant improvement was observed by addition of hydrogen, LPG, removal of CO_2 [14]. Admission of biogas generally increases ignition delay of pilot fuel; this will leads to advance the injection timing. Injection pressure, rate of injection plays important role in biogas fueled engines. The CO_2 in biogas slow down the combustion process, it also affects ignition. Thus a fuel with low self ignition could be used along with biogas to promote combustion. This kind of engine shows good performance than normal dual-fuel engine. The exhaust emission of diesel engine contains three substances which contribute air pollution, hydrocarbon (HC), carbon monoxide, oxides of nitrogen. The hydrocarbon emission depends on design and operating parameters. Usually in dual-fuel mode of operation with LBM the HC emission rate is more because of premixed air and fuel, in this case inducted charge is always lean, that leads to partial combustion [15]. The carbon monoxide (CO) emissions are considerably low compare to other gaseous fuel.

7. CONCLUSION

The study concludes production process of biogas and factors which influences on gas production rate. Attention is also focused for using biogas as fuel for diesel engines by different storage techniques. Gradation of biogas to bio methane is most economical. Different techniques for CO_2, H_2S scrubbing are discussed, among those water scrubbing is most effective. Study also clears that dual-fueling is recommended, is the best way for diesel engine operation. Use biogas reduces considerably the HC and CO emission rates are considerably low

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