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A CASE STUDY TO PURIFY BIOGAS USING SIMPLE WATER SCRUBBING METHOD AS SOURCE OF ENERGY FOR RURAL DEVELOPMENT IN INDIA

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ABSTRACT

The supply of petroleum fuels will gradually decrease and these will have to be replaced by other sustainable fuels. Natural gas is a fossil fuel that has many advantages as compared to liquid fuels like diesel and gasoline and has also been pointed out as a major alternative in the change over to sustainable fuels. Upgraded biogas has the same advantages as natural gas, which additionally is a sustainable fuel that can be manufactured from local waste streams thereby also solving local waste disposal problems. Biogas is a clean environment friendly fuel.

This work presents an experimental study of purification of a biogas to improve its quality by scrubbing the carbon dioxide (CO_2) and hydrogen sulphide (H_2S) contents. The results obtained are possible to deliver a biogas which is upgraded to natural gas quality for direct use as a vehicle fuel. By using local resources, which are available at agriculture fields, experimental set-up was developed. This set-up is simple for fabrication and operation by keeping low production and operation cost. The results obtained are encouraging and will make one of the options to use water scrubbing method on field side to upgrade the biogas as non-conventional energy source for direct use as a cleaner fuel for engines.

INTRODUCTION

The available alternate energy sources have to be studied for various applications for the energy needs. By evaluating the different energy sources, it is found that biogas can be accepted as one of the solutions especially to villages of India, where the conventional energy facilities are scarcely available. Biogas is a valuable fuel for energy containing methane as a responsible major constituent. It burns with a blue flame, which is soot free. It is a clean and efficient fuel.

Biogas contains some undesired elements like carbon dioxide, hydrogen sulphide, water, etc. which are needed to be scrubbed. The composition of CO_2 is 30-45% which is most undesirable and not useful. Also, traces of H_2S in bigas cause erosion to some extent. Methane has an octane number of 120 or more. Biogas, which is methane mixed with carbon dioxide, has a lower octane number than methane. Presence of carbon dioxide will dilute methane in the combustion chamber, because not as much methane can get into the cylinder, and clearly this will further reduce the power available from each power stroke in the cylinder. Removing the carbon dioxide will increase the power available. Also to improve the efficiency of engines, the traces of hydrogen sulfide from biogas should be removed if it is present in biogas in amounts (by volume) greater than 0.1 percent or 1000 ppm before its entry into the cylinders otherwise after biogas is burnt in the engine H_2S becomes SO_2 and causes erosion in the cylinders when it mixes with vapours. So, for clean and efficient biogas as fuel, carbon dioxide and hydrogen sulphide should be removed by using simple

with low cost scrubbing method which can be accepted as one of the solutions especially in villages of India.

THE NEED FOR PURIFICATION OF BIOGAS

Biogas is suitable as a fuel for most purposes, without processing. If it is to be used for powering vehicles, however, the presence of CO_2 is unsatisfactory, for a number of reasons. It lowers the power output from the engine, takes up space in the storage cylinders, and can cause problems of freezing at valves and metering points, where the compressed gas expands during running, refuelling, as well as in the compression and storage. All or most of the CO_2 must, therefore, be removed from the raw biogas to prepare it for use as a fuel for vehicles, in addition to compression of the gas into high-pressure cylinders, carried by the vehicle (Wellinger & Lindberg 1999). Hydrogen sulphide should also to removed to avoid formation of the corrosive gases which combine with water vapours to form acids, and hence corrode all metal parts of the engine and gas system.

The biogas composition can have a profound impact on the performance and emission characteristics of the engine. Flame speed, ignition delay, energy per cylinder and knock characteristics are affected by fuel gas composition, which affect the optimization of spark timing and air/fuel ratio. Understanding the impact of varying gas composition on engine performance and emissions is, therefore, important.

This work presents experimental study of purification of a biogas for removal of its carbon dioxide (CO_2) and hydrogen sulphide (H_2S) contents by using simple water absorbing methods.

PURIFICATION BY USING WATER SCRUBBING METHOD

The simplest and cheapest method of removing the CO_2 is by washing the gas with water under

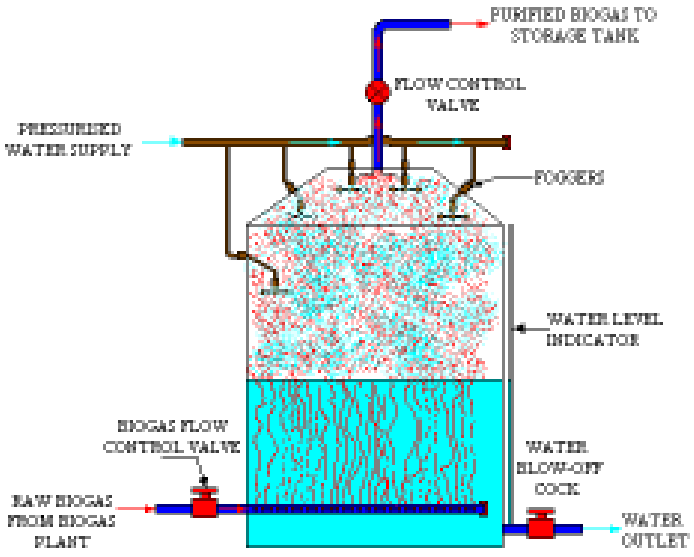

Fig. 1: Experimental setup for purification by water scrubbing method.

Table 1: Chemical analysis of biogas before and after purification.

Biogas contents	Percentage	Unpurified sample reading	Purified sample reading
Methane (CH_4)	%	48.23	58.20
Carbon dioxide (CO_2)	%	43.46	32.76
Hydrogen sulphide (H_2S)	%	06.21	02.12
Moisture	%	02.10	03.92

pressure (Shannon 2005). This method of scrubbing the biogas is capable of producing 100 % pure methane. This system produces 95% pure methane from raw biogas, originally containing 55% methane, which is pure enough for vehicle fuel. Hydrogen sulphide is particularly harmful when biogas is used in internal combustion engines. Its chemical reactions and those of its combustion product, sulphur dioxide lead to corrosion and wear on engines. The scrubber also removes all corrosive sulphides. So it is very essential to take the basic steps for purifying the raw biogas which can be used as vehicular fuel. So water scrubbing can be used to remove carbon dioxide but also hydrogen sulphide from raw biogas, since these gases are more soluble in water than methane. The absorption process is purely physical. Usually the biogas is fed to the bottom of the packed column where water is sprayed on top under pressure so that absorption process is operated counter-currently (Kapdi 2005).

EXPERIMENTAL SET-UP AND OPERATION

A scrubber is designed and developed from resources available locally like plastic barrel with height 1050 mm and 150 mm in diameter (Fig. 1). One of the easiest and cheapest methods involves the use of pressurized water (1.5 to 2 kg/cm^2) as an absorbent which is connected with drip irrigation system available on farm field side. This pressurized water connection is connected at top of the barrel with fine water spray foggers which continuously spray pressurized water from the top. The raw biogas is (not compressed) fed directly from biogas disaster store tank with low pressure into the packed bed column from bottom of plastic barrel. The absorption process is, thus, a counter-current one. This dissolves CO_2 as well as H_2S in water, which are collected at the bottom of the tower.

Samples of inlet and outlet biogas were taken during experimental tests. The composition of these samples was determined by gas chromatograph Chemito 2131 with TCD.

RESULTS AND DISCUSSION

Results show that 20.7 % increase in methane content after purification of the biogas and 24.62 % CO_2 and 65.86 % H_2S reduction due to dissolution in water, which are collected at the bottom of the tower (Table 1). This is the simplest method for scrubbing biogas designed to purify the biogas up to 60 % methane content at present. Pressurized water from top and low pressurized raw biogas from bottom is send in the scrubber in counter-current direction so that maximum absorption of carbon dioxide in water takes place. Purified gas is stored in storage tanks for further use.

CONCLUSION

The aim of this study is to utilize the large the potential of biogas production in India from animal waste. Presently, biogas is mainly used for cooking purpose in India. This potential of biogas may be used as vehicular fuel for rural India. Therefore, biogas scrubbing and storage in cylinders are

essential. Different methods of scrubbing are reviewed and found that water scrubbing is simple, continuous and less expensive method for CO_2 removal from biogas for Indian conditions. For biogas scrubbing, water absorption method is applied which can be effective even at low pressure flow rates. Also the method is less complicated, requires minimum infrastructure and is cost effective. It simultaneously also removes H_2S also. After removal of CO_2, biogas is enriched in methane and becomes equivalent to natural gas. It can be used for all such applications for which natural gas is used as a fuel for vehicles.

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