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Performance Evaluation of Cyclone Type Scrubber for Bio Gas and Comparison with the Water Scrubbing

Amit Choudhary[1], Dainik Savalia[2]
[1, 2]*Parul University*

Abstract: ***Nowadays the scarcity of fuel is one of the biggest economical problem which is related to the pollution for the world. Thus, in this scenario the biggest issue in front of the world is to develop a alternative fuel technology which can be economical as well as ecofriendly. The fuel to be used should also be having the less pollution capacity. India is the county which has the 70% of total pollution due to the agricultural activities. Thus, the biomass available in terms of agricultural waste and cow dung can be used for generation of methane/biogas using anaerobic digestion process. The most important content of the biogas is methane and also it consists of about 20% carbon dioxide. Thus, to remove such carbon dioxide water scrubbing and cyclone scrubbing are used and results are compared with methane analyzer is the main aim of present work.***
Keywords: Role of biogas as fuel, Biogas Scrubbing, Water Scrubbing, Cyclone type Scrubbing.

I. INTRODUCTION

Major portion of the energy utilized in the present scenario is supplied by fossil fuels and the burning of this fuel results into the waste materials, which mainly consists of the emissions to the atmosphere in the form of burned fuel gases, dust, etc. These burnt waste materials have very harmful effect on the environment. The continuous utilization of large amount of fossil fuels creates a serious threat to the environment. Also, the fuels are finite in quantity. At the start of the 21st century almost half of the fossil fuels had already been consumed. Another major problem with fossil fuel is the emission of pollutants consisting of CO_2, NOx, CO and hydrocarbons (HC) to the environment. So, the world needs to search for other such resources of fuel and now a days those fuels are required which are most useful and eco-friendly. These sources consist of gaseous fuels. Gaseous fuels have very high flammability limits and can easily form a homogeneous mixture with air for good combustion. One of the fuel consisting of less pollutant and highly eco-friendly is bio gas.

Biogas is one of the major sources of energy in the rural areas. The production of the biogas can be done from the cow dung, animal waste and also from leaves. All of these resources are renewable and available in abundance in the rural areas. The composition of biogas mainly consists of methane, Carbon dioxide, Hydrogen, Nitrogen and various other impurities such as hydrogen sulphide. All of these components of biogas lie within the ranges of 50-70% (methane -CH_4), 25-50% (Carbon Dioxide-CO_2), l-5% (Hydrogen-H_2), 0.3-3% (Nitrogen-N_2). Hydrogen sulphide(H_2S) provides the biogas the bad odder and it is also responsible for corrosion. The carbon dioxide present in the biogas helps in reducing the combustion which ultimately affects the performance of the engine. Percentage of methane and carbon dioxide in biogas pends on the the maturities of feed stock, temperature, water content, loading rate of raw material and bacterial actions. Biogas has the property of clean-burning, also it can be easily produced. Natural fuel is becoming a more important source of energy in rural. Most of the developing countries are utilizing the biogas for cooking and heating. Also, after the scrubbing of Methane, the scrubbed methane can be utilized as the fuel in vehicles and also can be utilized in the cooking purpose.

Hilkiah Igoni [1] studied the result of Total Solids Concentration of Municipal Solid Waste on the Biogas Produced in an Anaerobic Continuous Digester. Kumar et al. [2]studied the reactivity of methane. They both studied and concluded that methane has global warming potential of about 20 times the global warming potential of carbon dioxide.

Shalini Singhet al. [3]studied the process to increase the production of biogas using the microbial stimulants.

Tri Ratna Bajracharya, Alok Dhungana, Nirajan Thapaliya, Gogan Hamal [4] studied and developed chemical scrubbing methods for biogas cleaning.

S.S. Kapdi [5] et al.studied and worked on to improve the quality of biogas by scrubbing CO_2 and obtained the results. Biogas has lot of potential which can be utilised for the vehicles by fuel like CNG. The CNG can be obtained by compressing it and filling it into the cylinders. S.S.KAPDI suggested that various processes are being used by Petrochemical industries to remove CO_2 from natural gas. This process consists various processes such as Physical absorption, Chemical absorption, Adsorption on a solid surface, Membrane separation, Cryogenic separation, water scrubbing etc.

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E. Porpatham [6] et al.studied experimental influence of reduction in the concentration of CO_2 in biogas. He also studied on performance, emissions and combustion in a constant speed spark ignition (SI) engine. The tests covered the range of equivalence ratios from rich to the lean operating limit at a constant speed of 1500 rpm and at compression ratio of 13:1.

The process of removing the carbon dioxide from the biogas is called scrubbing of bio gas and in the present work done following two methods are studied to obtain the highly scrubbed Methane from biogas.

1) Water Scrubbing.

2) Cyclone Scrubbing.

The above two methods are compared to explain the better technique for the biogas scrubbing.

II. EXPERIMENTAL SET UP

1) *Components for Water Scrubbing:* For the water scrubbing the MS pipe having the dimensions 6 inches diameter and 6 feet height is utilized. The other components utilized for the water scrubbing are Submersible pump, Metal mesh, PVC flexible pipes and methane analyzer. All these components utilized was provided by the Muni Seva Ashram Vadodara. The tabulated form of the components utilized is as shown in the table below:

The setup for water scrubbing is as shown in the figure 1.

Name of Component	Dimension
MS pipe	6” diameter and 6’ height
Submersible Pump	10’ head 1500LPM discharge
Metal Mesh	300 µm
PVC Flexible pipes	0.5” diameter
Methane Analyzer	-

2) *Components for Cyclone Scrubbing:* For cyclone scrubbing the MS sheet is utilized for manufacturing the setup. This MS sheet is having the thickness of 1mm.The other components required for this setup are PVC flexible pipes, Ball Valve and Methane Analyzer. The following table indicates the components required for the Cyclone type scrubbing.

The setup utilized for the same is shown in figure 2 and figure 3.

Name of Component	Dimension
MS sheet	1 mm thick
PVC Flexible pipes	0.5” diameter
Methane Analyzer	-
Ball Valve	½” diameter brass made





Fig 1 Water Scrubbing UnitFig 2 Cyclone Scrubbing Unit

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Fig 3 Top View of Cyclone Scrubbing Unit

Methane analyzer is a device which indicates the percentage of methane which is scrubbed from the biogas. The methane analyzer is as shown in the figure below. This device is required in any of the scrubbing technique as it helps us in indicating the rich methane percentage. The arrangement of Methane analyzer is as shown in the figure 4.



Fig 4 Methane Analyzer

A. Methodology

In case of water scrubbing first of all the flexible pipes are connected to scrubber along with the water supplied lines with submersible pump and water drain system. Also, these pipes are fitted to the inlet of the biogas and the other end is connected with the collection unit of scrubbed biogas. The gas is purged from the bottom of MS pipe and water is sprayed from the top of the pipe. The gas which is coming out from the top of pipe is collected and analyzed using methane analyzer.

In case of cyclone scrubbing the gas is purged from top left side of the cyclone separator. Due to the difference in the density of methane, the purified methane comes out from the outlet provide at the top of cyclone scrubber. Another setup is also done to obtain the higher rise in the scrubbed methane by connecting the two cyclone type scrubbers of same dimensions and size in series.

The setup with CAD model is as shown in the figure below:

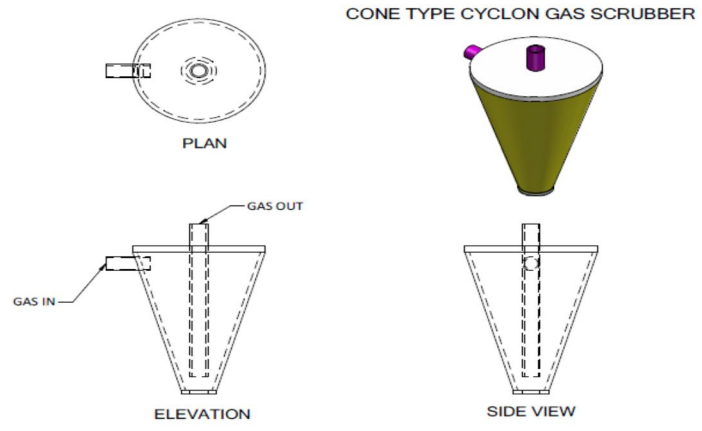


Fig 5 CAD model of proposed experimental setup

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Fig 5 represent CAD design of cyclone scrubber and the whole structure is made of mild steel and fabricated using arc welding with dimensions are of top diameter of 6" and length of cyclone is 2' and all pipes are of 1" diameter. At the center of cyclone 1" diameter pipe is fabricated which is 3" above from the bottom of cyclone though which separated methane (CH_4) comes out from top of the pipe and carbon dioxide gas comes out at the bottom portion of cyclone. The basic working principal of separation of gases on the basis of density difference.

The results obtained after the single stage scrubbing indicated the reading of 36% scrubbed methane. Further for obtaining the better results the scrubbing of methane was carried out in the series connection of two cyclone type scrubbers. Both the cyclone type scrubbers were connected in the series as shown in the figure 6.



Fig 6Two setups in series connections.

The observations obtained by the two setups are as shown below:



Fig 7 Observation after single stage scrubbing

The above observation indicates that the percentage of scrubbed methane is about 56% in the single stage of scrubbing of biogas.

For the better results two cyclone type scrubbers of same dimensions were connected in the series to obtain the scrubbed methane. The results obtained after the double stage scrubbing is as shown in the figure below:



Fig 8 Observations obtained after double stage scrubbing

Fig 8 indicates the percentage of scrubbed methane obtained after the series connection of two cyclone type scrubbers is 64%. There is a rise of about 8% if the scrubbing is done in two stages.

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III. RESULT AND DISCUSSION

With the help of methane analyzer, the scrubbed gas in all the three cases are analyzed and results obtained are explained in the tabular format as follows:

Scrubbed Methane in Water Scrubber	Scrubbed Methane in Cyclone Scrubber	Scrubbed Methane in series connection of cyclone scrubber
5 %	56 %	64%

As shown in the above table in case of water scrubbing the amount of moisture found is higher in comparison to the cyclone scrubber and so to remove this moisture silica gel has to be used for the gas to be scrubbed from the water scrubber. During the water scrubbing the scrubbed methane obtained was about 5%.

As shown in the above table in the two setups arranged in the cyclone type scrubber, the scrubbed methane produced is about 56% in the case of the single stage scrubbing and 64% in the case of the series connection and the double stage scrubbing.

As compared to water scrubber, cyclone scrubber technology is simple and easy to handle.Also, there is no need of any medium in case of cyclone type scrubber which is one of the biggest benefits of the cyclone type scrubber. Also, there is no presence of moisture in the case of cyclone type scrubber so there is no need of any kind of silica gel to remove moisture.

IV. CONCLUSION

In comparison of water scrubbing technology cyclone scrubbing technology is more compact and easier to handle. The results obtained are also better for the biogas scrubbing point of view.By using single cyclone scrubber additional pure methane can be obtained in comparison of raw biogas. When two scrubbers are used in series the gain in methane percentage is comparatively very higher in comparison of raw biogas which may be due to parallel scrubbing taking place in the second cyclone scrubber. To obtain the better results in case of water scrubbing lot of changes in the dimension is required.

One of the important point that can be concluded from the above setup is that it is highly cost effective as compared to the other biogas scrubbing techniques.

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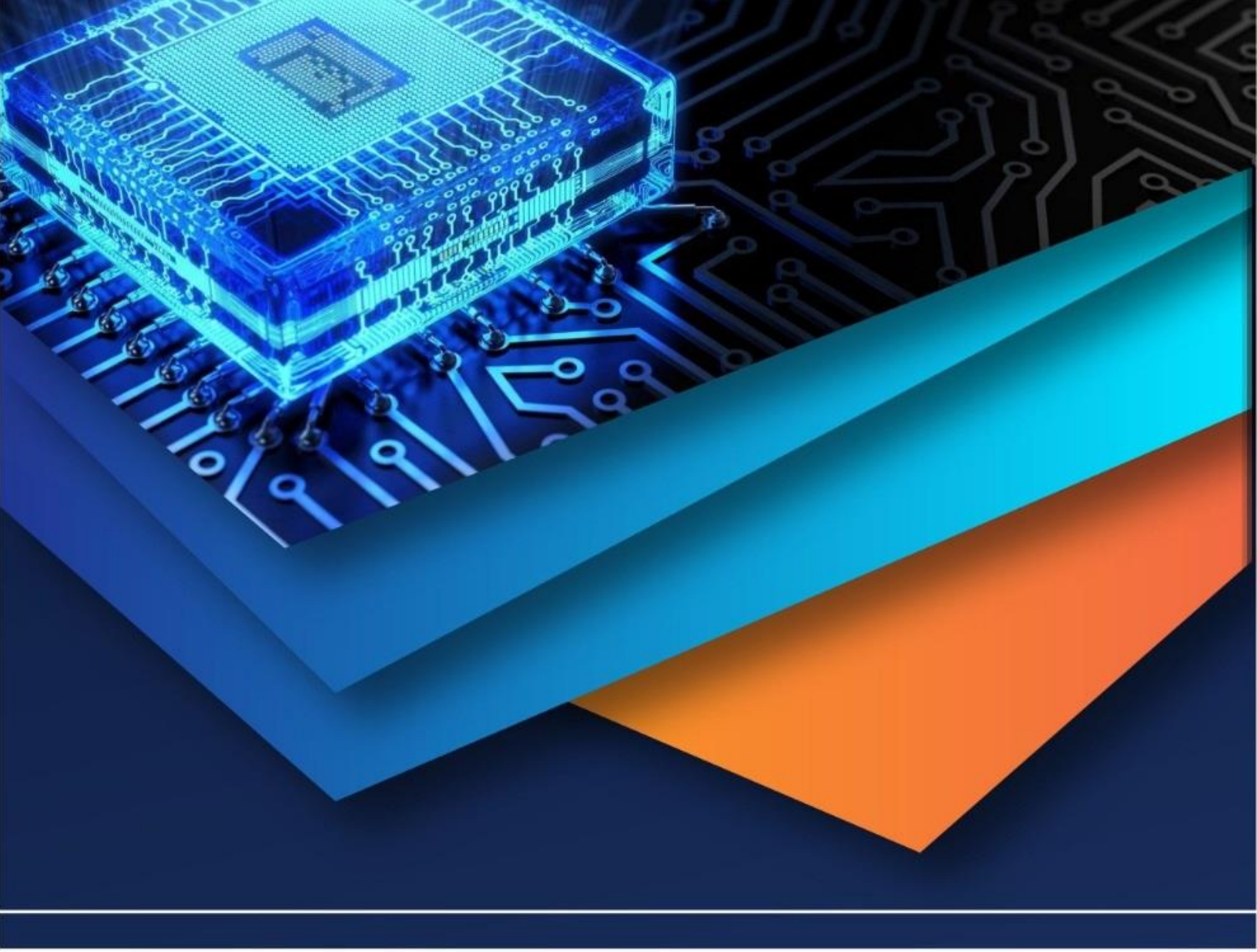
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