Design and Experimental Studies on Compact Anaerobic Digester for Biogas Applications

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***Abstract*- Energy Consumption has increased steadily over the last century as the world population has grown and more countries have become industrialized. Due to the increasing demand for fossil fuels and environmental threat, a number of renewable sources of energy have been studied worldwide. Biogas, a clean and renewable form of energy could very well substitute (especially in the rural sector) for conventional sources of energy (fossil fuels, oil, etc.) which are causing ecological-environmental problems and at the same time depleting in a faster rate. In this work, different feed stocks with boiled condition were used as feedstock for producing biogas. This project reviews the important parameters like temperature pressure, total solid concentration, and hydro retention time (HRT) which could be used to enhance the gas production rate from solid substrates under mesophilic condition with temperature ranging from 28^{0}C to 36^{0}C. A closed type portable digester (batch type process) was used. The biogas produced from cow dung was initially extracted and then it is compared with experimental study by using different feed stocks such as Organic wastes, kitchen wastes and various industrial wastes.**

***Keywords*： *Biogas, Hydro retention time, Digester , Feed stocks*.**

I. INTRODUCTION

Energy is an essential input for economic growth, social development, human welfare and improving the quality of life. As a result, consumption of energy in all forms of has been steadily rising all over the country. This growing consumption of energy has also resulted in becoming increasingly dependent on fossil fuels such as coal, oil and gas. Increased usage of fossil fuels also causes environmental problems both locally and globally. It is common knowledge that the world's main energy resources will be depleted within next few decades. Hence, the scientists are looking for alternative fuels, correlation with sustainable development, energy conservation, management, efficiency, and environmental preservation, has become highly pronounced in the present scenario. In view of this, researcher found and analyze many energy sources like CNG, LNG, LPG, ethanol, methanol, biodiesel, biogas and many more. Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as manure, sewage, municipal, green waste, plant material and crops. Biogas comprises of mainly methane (CH4) and carbon dioxide (CO2) and small amounts of hydrogen sulphide (H2S) and moisture. The gases such as methane, hydrogen and carbon monoxide (CO) can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel. Biogas can be used as a fuel for any heating purpose, such as cooking. It can also be used in anaerobic digesters where it is typically used in a gas engine to convert the energy in the gas into electricity and heat.

II. DIGESTER

The organic waste is generally processed, liquefied, and pasteurized to rid it of pathogens and make its breakdown easier for the anaerobic bacteria. These bacteria, commonly found in soil and water, first employ enzymes to convert the waste matter into amino acids and sugars and then ferment these into fatty acids. The fatty acids are then transformed into a gas, This whole process of anaerobic digestion takes place in a sealed, water proof chamber known as an anaerobic digester. The digester is generally cubical or cylindrical in shape and may be constructed of brick, concrete, steel or plastic. The liquefied organic waste is fed into the digester chamber through a pipe and exposed to the anaerobic bacteria that flourish there under optimum temperature ranging between 95 degrees Fahrenheit (35 degrees Celsius) and 140 degrees Fahrenheit (60 degrees Celsius).

The reactions taking place inside digester is carried out in four phases.

- Hydrolysis: Macromolecules are cut gradually soluble monomers by extracellular enzymes.
- Acidogenesis : Monomers derived from the hydrolysis step, are converted to organic acids and alcohols with a released ammonium (NH_4+), carbon dioxide (CO_2) and hydrogen (H_2),
- Acetogenesis : The products of acidogenesis are converted into acetic acid (CH_3COOH), but also CO_2 and H_2, the main substrates of methanogenesis.
- Methanogenesis : The final step in which the methane is formed as two separate channels and main, the acetate and the mixture of H_2/CO_2.

III. BIO DIGESTER DESIGN

The design for the anaerobic digester is done using SOLIDWORKS software. The digester is made of 0.6m^3 capacity of volume with a diameter of 85 cm and height 100 cm. By considering the amount of wastes to be fed inside, the digester design has made. All perforations were properly sealed to make the whole digester system airtight. The inlet and outlet line were given on both sides of digester using 3" and 4" PVC pipes.

DESIGN CALCULATIONS:

Volume (V) = $0.6m^3$

Length (L) = 1m

To find Diameter (d):

$V = \pi/4\ d^2*L$

$0.6 = 0.785*d^2*1$

d = 0.85 m

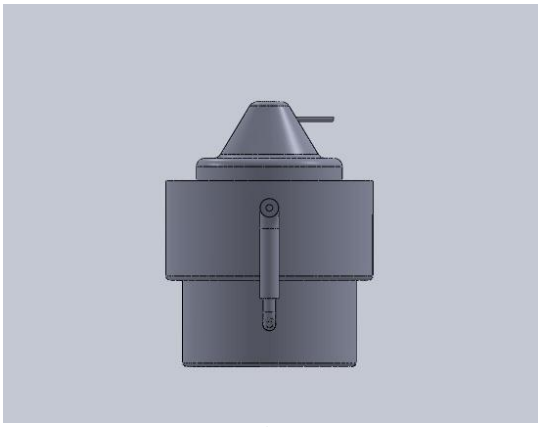

Fig. 1 3D Design of Anaerobic Digester

Fig. 2 Anaerobic Digester

IV. MATERIALS AND METHODS

The following materials were used for the purpose of this research work: Bio-digester, Inlet Funnel, Inlet pipe, Slurry outlet, Gas outlet valve, Bunsen burner and feedstock.

EXPERIMENTAL METHODS

The stages involved in the procedure for experimental study are:

Stage 1: The preparation of the substrate
Stage 2: Decomposition process
Stage 3: Collection of data
Stage 4: New substrate introduction
Stage 5: Analysis of the gas produced.

Stage 1: Preparation of the Substrate

In this stage, a total of 2 kg of cow dung was weighed and mixed with water and then fed into the 2/3 of the bio-digester. The dung is mixed 50:50 ratio with water as the substrate should not be too thick or too diluted as it may increases acidity and reduces gas production.

Stage 2: Decomposition Process

In the decomposition stage, due to the anaerobic conditions, microorganisms start degrading the dung for their survival, starting biogas formation process. This decomposition process happens with the help of reactions such as Hydrolysis, Acidogenesis, Acetogenesis and Methanogenesis. This set up was kept under room temperature of (25-35^{0}C) for the bacteria to act on the substrate. After the process undergoes decomposition for 3 days, the 1st gas production was observed. This buildup continued for 22 days and data buildup with time and volume was taken on daily basis.

Stage 3: Collection of data

This stage involved the method by which data is been collected on a daily basis. The gas generation with time for every day was recorded at an interval of 24hours (i.e.11am daily). Also the temperature range should be maintained.

Stage 4: New substrate introduction

After 20 days, the new substrate is prepared with the help of kitchen wastes and 3kg of kitchen wastes such as waste food, rotten vegetables are fed in to the digester. After 12 hours of feeding, we can observe that gas is formed as the top cover expands. The data of volume of gas generation with respect to the quantity of wastes are taken for analysis. The experiment is repeated with the introduction of leaves wastes and data analysis is taken after 12 hours of feeding.

Stage 5: Combustible test

The combustion test took place after the biogas production. The test was conducted by using Bunsen burner and the gas burned with blue flame without soot. Combustible test is mainly to find the hours/day for the gas generation. Finally experimental study on different feed stocks is made.

V. EXPERIMENTAL RESULTS

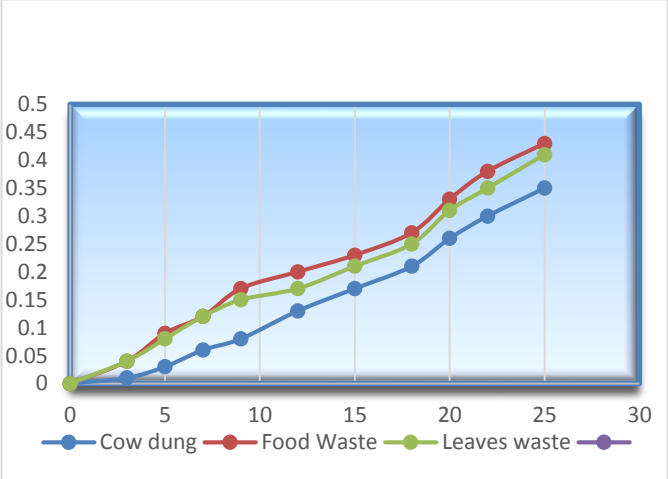

Fig. 3 Volume of Gas Production with respect to Time (days)

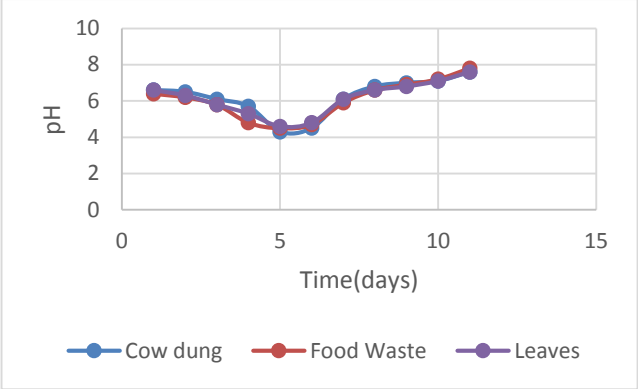

Fig. 4 pH Range with respect to Time (days)

VI. RESULT AND CONCLUSION

In this work, three feed stocks such as cow dung, kitchen waste and leaves waste were attempted for biogas production using floating drum digester. Results revealed that the maximum gas production was found in kitchen wastes compared to cow dung. The study revealed that it is possible to produce biogas from kitchen waste since it has more nutrient than cow dung. Therefore it could be stated that kitchen waste is a good raw material for biogas production as an alternative source of energy. By removing moisture in the gas we could utilized the biogas directly for conventional domestic use and also to run the I.C engine by minor modifications. By considering the vast and cheap availability of various feed stocks the biogas process could be used to fulfill the future energy demand in eco-friendly manner.

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