PERFORMANCE EVALUATION OF FLXI BIO-GAS DIGESTER FOR PRODUCTION OF METHANE AS DOMESTIC FUEL

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ABSTRACT

An FLXI bio-gas digester made out of very strong rubberized fabric was installed at Physics Field Station Facility at UPNG. Chicken waste and water were used in equal amounts as slurry for anaerobic digestion to produce methane gas. Initial results indicated that the combustible gas was produced along with a combination of other gases as perturbations to the production of methane.

KEY WORDS: *chicken waste, anaerobic process, combustible gas*

INTRODUCTION

Bio-gas is a renewable energy resource which is produced as a result of biological fermentation of organic materials such as agricultural wastes, manures, animal and human excreta and the organic effluents etc in an anaerobic (oxygen-deficient) environment. The fermentatioin produces a mixture of methane (CH_4)/carbondioxide (CO_2) and other methanogenic gases reducing the organic materials to a slurry waste. The left over waste contain high concentrations of nutrients which make them highly effective as fertilizers (Srivastava, 1997).

Production of bio-gas in the rural sector of many developing countries has helped them indirectly to (i) improving the general sanitation and, therefore, reducing the community health problems: (ii) saving women from the drudgeries of collecting wood-fuel; (iii) protecting forests and deforestation; (iv) reducing pollution from smoke; (v) providing low-level employment opportunities and (iv) increasing agricultural yield by the application of bio-gas fertilizer etc. The basic technologies used for the conversion of organic materials to bio-gas are quite soft, environmentally clean and economical to establlish, operate and maintain. These are particularly well-suited for use in agricultural areas where the organic feedstock is more readily available.

Currently, a large number of bio-gas digesters are in operation with several of them being in China (approx. 1.3 million), India (approx. 1.3 million), South Koria (approx. 30,000) and Brazil (3,000); in addition to a few tens of hundreds in other developing countries. All of these utilize two basic designs: the fixed dome (Chinese) and the floating cover (Indian) concept. Yet another design which has been developed recently by an Indian Company in the form of a bag digester, was used at the Physics Field Station on Waigani Campus for experimental purposes and will be discussed in this article.

THE PROCESS

Anaerobic digestion is a process in which the anaerobic bacteria are able to exist through degradation of the general carbohydrate material. The process is partly dependent on temperature and partly on the C/N (Carbon/Nitrogen) ratio in the fuel stock material. Usually, higher the temperature, faster is the digestion with optimum temperature range being 30-40^{0}C for methanogens (methane producing bacteria). For the C/N ratio, the optimum range is from 20:1 to 30:1. A ratio higher than 30:1 restricts the microbial process due to lack of nitrogen for cell formation while too low a ratio increases the shift towards ammonia toxicity.

Generally, the tropical and sub-tropical regions with large numbe rof animal stock and with predominantly agro-economies find a more suitable environment for bio-gas production.

AN EXPERIMENT

During the middle of 1997, a new flexible and easily transportable bag digester was experimented for the production of combustible methane gas under a project sponsored by UPNG. The experiment was conducted using chicken waste as intake for the anaerobic process.

Messrs Ilimo Poultry Products Pty Ltd provided us a free supply of chicken waste which was transported to the Physics Field Station in appropriate bags. Messrs Swastik Rubber Products Ltd of Maharashtra. India provided us the FLXI Bio-Gas plant at subsidized rates for research purposes.

pegs. Next, the inlet funnel was positioned on the tripod and the outlet was positioned on the "Y" stand. The level of the outlet was kept at about 75 cm which was approximately the same at which the plant was expected to rise aster filling with the slurry. The plant was then ready for filling.

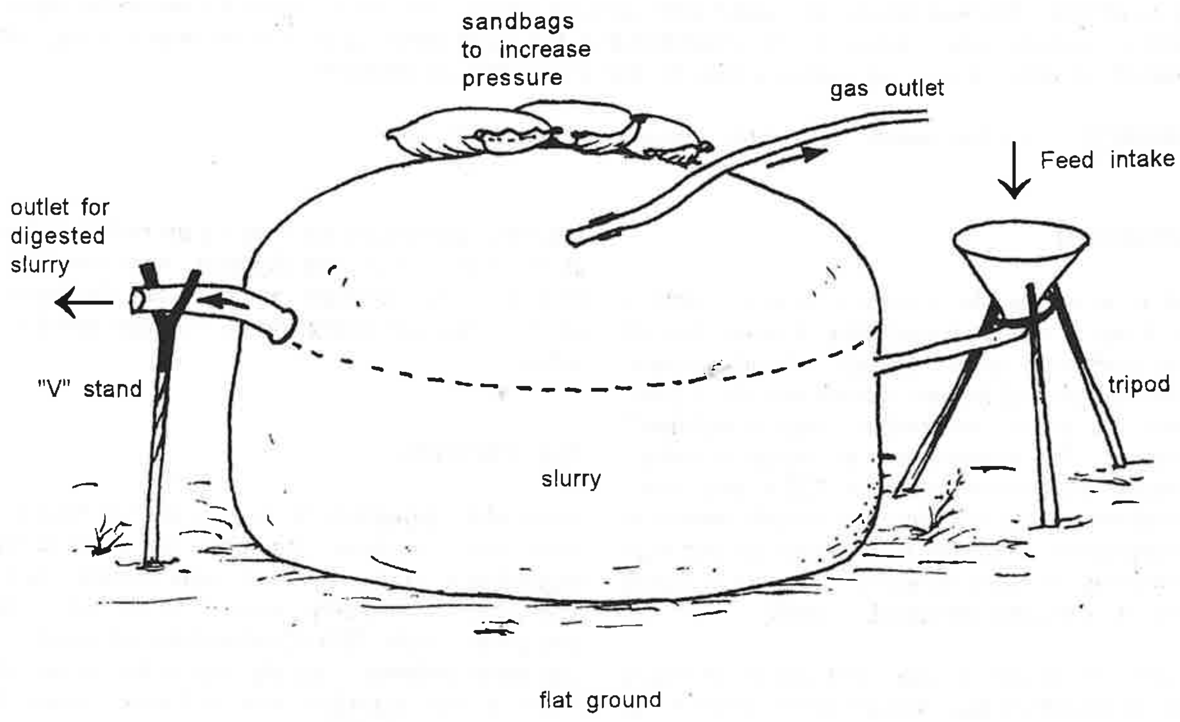

Figure 1. **FLXI Bio-gas Digester.**

The plant was made out of very strong rubberised fabric and was a compact and a highly flexible system for the generation of bio-gas. The bag digester system was of 3m^3 capacity and is shown in figure 1.

System Installation

The system shown in the figure as above was first laid on a level ground without the slurry inside. It was made sure that the ground was flat and did not have any sharp projections or stones. This was to protect the flexible bag from tearing during the filling operations. The straps which were provided on the bottom of the plan were then pulled in opposite directions and were tied to the wooden

The slurry was prepared by mixing equal amounts of chicken waste with water and was poured into the plant by means of a bucket through the inlet funnel till it rose to the height of approximately 75 cms from the ground. It was ensured while preparing the slurry that the grass, straw, hay twigs, stones are all removed from the mix and that all wrinkles, folds, etc., are in the middle while filling the slurry so that the plant remains upright and does not tilt. The inlet was then tightly closed as also the gas outlet with the stopper.

A flexible gas pipe was used between the plant and the rigid burner point. This was to ensure that the gas outlet immediately outside the plant slants upwards so that any moisture which is produced would fall back intot he plant and not choke the gas pipeline. A stop valve was also fitted to the distributor pipe immediately after the flexible hose pipe.

Observations

It was observed that within about two to three days, the gas had actually started to form. We had to place a few sand bags on top of the plant for pressurising the gas through the pipe. The gas had actually bulged the holder against the weight of the sand bags.

In the beginning, for roughly about 18 to 20 days, the gas was supposed to be rich in CO_2 and was of no use to us. This had to be let out everyday by removing the gas outlet stopper. It was important because any pressure build-up would have ejected the slurry out of the plant.

We had observed the build-up of pressure from the gas outlet to be slow in the beginning because of not enough sand bag pressure from the top. It had however, increased when more bags were added on top.

The gas that was generated from roughly about three to four weeks onwards, would have had methane in it. This was tested to be so but only after a lapse of about five weeks. The period for the production of methane can vary due to variations in daily temperature and also with the type and the quantity of the feedstock. In Port Moresby during the operational months of June to August and with chicken waste as our feedstock, we had found the hydraulic retention time to be roughly about five weeks for initial total slurry of 4500 kg. The useful gas under these condition would have been generated in approximately three to four weeks time.

Our intention for the experiment had not been to use the gas that was produced for any working purposes in as much as to test its production through the bag digester. The combustible gas was successfully produced and was tested to flare up when ignited through the matchstick. The pressure was not large enough to produce a continuous flame at the top of bunsen burner. It did, however, indicate that the anaerobic process had generated a low pressure gas effectively with operations through flexible bag digesters.

The gas sample was also taken for analysis through the 'Fourier Transform Infrared Spectrophotometer' to check for its constituents under the carbon chain. The sample was found to contain a mixture of other methanogenic and carbon chain gases besides the combustible methane gas. This had indicated that the intial production of CO_2 in the early stages may not have been fully eliminated, thus, hampering the combustion process to some extent.

RESULTS

A number of important and somewhat new features have now hecome available from the experiment which was conducted on bio-gas production using the flexible bag digester. These results are likely to form the basis for any future works on the commerical size installation of bio-gas plants in Papua New Guinea.

It is now quite apparent that the FLXI bag digesters can be successfully utilized for the production of bio-gas in Papua New Guinea. The digesters which come in ready to install units up to 4m^3 size, could even be custom-built for bigger sizes and require no masonry or metal work etc. These are fairly easy to operate with simple pouring of slurry, do not need any protective painting or masonry repair work and are extremely cost-effective.

Another advantage, which although was not required for our project, is when we need to transport the bio-gas from the generation plant to the consumers. This can be done easily with the availability of a compact, lightweight and collapsible balloon. The balloon comes in various sizes and the whole operation can become similar to LNG cylinder distribution outlets with filling plants located centrally.

For the bag digesters to operate efficiently, we have also found that the feed-stock should be fed into the bag semi-continuously with the feed displacing an equal amount of slurry removed from the outlet. Since the plant is flexible, care should also be taken to remove the skum which is a thick dry layer formed on top layer of the slurry, by jolting the plant daily. This increases the gas production.

In terms of sizes, bio-gas digester have been developed to cater for a wide range of bio-gas demand but in general, the community-size plants of capacity greater than 40m^3 work out to be more efficient than the household plants due to their economies of scale and better associated operation and maintenance.

GENERAL REMARKS

Bio-gas is available only at quite low pressures compared to other commonly used gases, eg, propane, brutane, etc. The stoves, therefore, for burning bio-gas efficiently must be designed in a manner so that the ratio of the total area of burner parts to the area of injector orifice in somewhere between 200 to 300:1. There is a general need, in fact, for improving and standardising he bio-gas burner (V.V.N. Kishore, 1993).

The other and perhaps a more important factor to be considered is the availability of the feedstock for digestion. In PNG, chicken and the pigs waste are the only animal waste resources which can be made readily available. In our experiment with the chicken waste, we have found that it can be gainfully employed to produce bio-gas. Similar experiments, however, have to be carried out using the piggeries waste.

In general, there is a need to develop designs utilizing alternative feed materials such as crop residues. This would significantly enhance the potential for bio-gas production for smaller countries with less number of animals. The agricultural waste that should be experimented in PNG is baggasse (waste from the Ramu Sugar Ltd) and coffee husk from coffee plantations which is plentiful in PNG.

Last but not the least, the bio-gas manure which comes as a by-product fromt he production of methane, is considered to be a good quality fertilizer. However, if suitable methods of processing the biogas manure to saleable product can be develped, the entire economics fo the bio-gas system can improe significantly.

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