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Design and Development of Floating Prototype Bio-digester.

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ABSTRACT

This paper gives some background information on production of biogas using animal waste. The design and development of a floating type bio digester installed at Energy Center, Maulana Azad National Institute of Technology Bhopal is discussed in this paper. The bio digester is a prototype for studying and producing bio gas. It is made of galvanized iron and is portable. The design aims to fulfill cooking and lighting demands of rural Indian population. The designed bio digester is able to address all issues related to any biogas plant; cleaning, odour, manure extraction etc. The digester is designed to be perfectly user-friendly and safe from any gas leakage.

Keywords: Biogas, Biomass, Rural.

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INTRODUCTION

India is a country that is abundant in renewable energy resources. Alternative resources such as solar, wind, bio-mass etc are available in plenty. But these resources have not been exploited and utilized properly. India faces an acute power shortage. The rural sector lags a huge phase behind the urban sector in this context. The energy needs of urban India are mostly met by conventional energy resources and methods. Thermal power plants dominate the power scenario in India, followed by Hydro and Nuclear. The fossil fuels such as coal and petroleum are racing to quick depletion. Also, the threats of global warming and climate change have been in the air. Hence, it is very much necessary to utilize the existing alternative sources of energy.

One of the ways to exploit the renewable resources is to utilize the bio-mass available in India. The idea is to fulfill cooking and lighting needs of the rural sector by production of bio-gas. The construction and development of the bio-gas digester began in the early 1920s and now it is very widespread among all countries. In India, bio-gas generating plants using cow manure have been in operation for many years. In Taiwan more than 7500 bio-digesters have been constructed, which use pig manure. It can provide cooking, heating, drying, lighting needs of a community provided that the capacity of biogas plant is sufficient. Biogas plants are also used to provide natural manure which has a very high content of nitrogen and other nutritious element like phosphorous etc. This manure is free from any fertilizer and can be extensively used in farming. Hence the technology of bio-gas generation is very advantageous, as it can cater to the energy needs of the rural community and households.

MATERIALS AND METHODS

Production of bio-gas

Biogas is a mixture of methane, carbon dioxide, small amounts of carbon monoxide, hydrogen, nitrogen, oxygen, and hydrogen sulphide gas. Typically, the composition of biogas is as follows in Table No 1 [2].

Table: - 1

Gas	Percentage of content
Methane	54-70%
Carbon dioxide	27-45%
Carbon monoxide	0.1%
Oxygen	0.1%
Nitrogen	0.5-3%
Hydrogen sulphide	Trace
Hydrogen	1-10%

Biogases are obtained by fermentation of organic materials such as animal, human, agricultural and industrial wastes. Anaerobic digestion of organic matter occurs in three phases; the first phase in which facultative microorganisms convert complex organic compounds into less complex organic compounds. In the second phase, a group of bacteria converts these soluble monomers into acids and in the third phase, the soluble organic acids serve as substrate for methanogenic bacteria. These bacteria produce methane gas by two ways; either by

fermenting acetic acid to methane and carbon dioxide or by reducing carbon dioxide to methane via hydrogen gas as shown in the reactions [1] given below:

$n(C_6H_{10}O_5) + nH_2O \xrightarrow{\text{hydrolysis}} n(C_6H_{12}O_6)$

$n(C_6H_{12}O_6) \longrightarrow 3nCH_4 + 3nCO_2$

$CO_2 + 4H_2 \xrightarrow{\text{reduction}} CH_4 + 2H_2O$

$CO_2 + H_2O \xrightarrow{\text{hydrolysis}} H_2CO_3$

$n(C_6H_{12}O_6) + 3nH_2O \xrightarrow{\text{hydrolysis}} 3nCH_4 + 3nH_2CO_3$

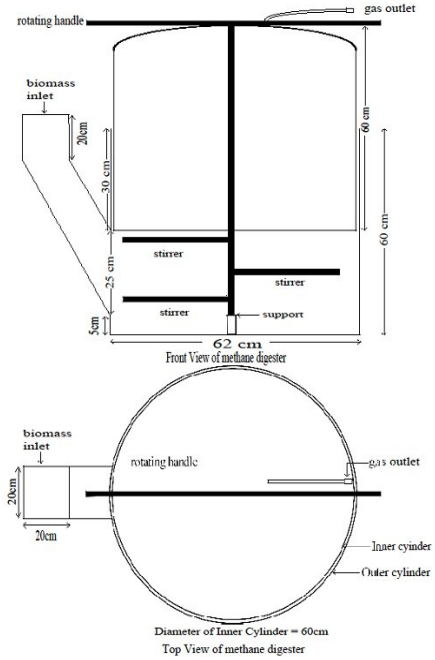
$H_2CO_3 + 4H_2 \xrightarrow{\text{reduction}} CH_4 + 3H_2O$

Temperature has a significant effect on biogas production. Two temperature ranges have been reported to affect the overall process of biogas production. These are: the mesophilic range (30-40^{0}C) and the thermophilic range (> 40^{0}C). The gas production is optimum in the mesophilic range. This range is preferred when fresh plant material is involved. Methanogenic bacteria are very sensitive to sudden thermal changes and therefore any drastic change in temperature should be carefully avoided. Anaerobic digestion process can be operated over pH range of 6.0-7.0.

Bio-digester and its types

Methane is made by the anaerobic digestion of manure and plant life. The purpose is to convert this manure into methane to use as cooking fuel. One method is to use a circular pit made of concrete, that is sealed and manure is added over time. Pipes lead from this container into the house, where gas is emitted at the cooking location. Another method is to construct a small scale floating type bio-digester. Generally it has two containers. The upper container rises up as the gas is formed. The advantage of this type is that it is portable and can be made on a smaller scale. The design of the floating type digester is shown below.

Design digester



Design

The above diagram shows the front view and the top view of a portable floating type bio-digester. As shown in the design above, the various parts of the floating type digester are; inner cylinder, outer cylinder, biomass inlet, biogas outlet, stirrer, rotating handles and support.

The outer cylinder is made out of iron and has a diameter of 62 cm and a height of 60 cm. The whole set of reactions is carried out in this cylinder. A mixture of biomass, water and catalyst (such as dry leaves, water hyacinth etc) is fed into this cylinder through the inlet provided at its side. This inlet container is a uniform cube of dimension 20 cm x 20 cm, that runs down to the cylinder.

The inner cylinder is placed on top of the outer cylinder and it houses the rotating handle, the stirrer and the gas outlet valve. Its diameter is 60 cm. It has a height of 60 cm. This cylinder floats on top of the raw materials and the biogas is collected within. As the gas starts forming, it rises above, thus facilitating more space for the gas and more output. Hence it has dynamic storage capacity.

The stirrer consists of a long vertical G.I rod and four horizontal rods at the bottom, fixed firmly on the support. The rotating handle on top is another iron rod which rotates the stirrer as it is rotated. This can be either done by hand or by cattle. As and when the stirrer is rotated, the ingredients of the slurry get mixed, so that proper reaction can take place.

The main advantages of this type of bio-digester are that it is portable and can be made on a very small scale. It is not space consuming. It has dynamic storage capacity as in the case of inner cylinder and the hazards due to leakage are minimal.

Costing

Table No 2 show costing for the construction of Portable floating bio digester of volume 0.272 m^3

Material	Quantity	Unit Cost	Total Cost
18 gauge galvanized steel sheet	23 kg	Rs 40/kg	Rs 920
2" G.I. rod	3.15 kg	Rs 40/kg	Rs 126
2 mm G.I. Right Angle bar	3 kg	Rs 50/kg	Rs 150
Valve	1	Rs 190/valve	Rs 190
2 mm G.I. Strip	0.75 Kg	Rs 30/kg	Rs 23
Sheet cutting and welding expenses			Rs 250
Labor charges			Rs 200
Total			Rs 1859

CONCLUSION

The digester is designed keeping tropical climate in which majority of India's landmass falls. The weather is generally dry and average temperature of the day is about 30^0C in summer while 18^oC in winter [3]. Since its implementation is specifically for rural India it has been made compact in size and very easy to use. No skilled labor is required for proper functioning of the digester and this feature is most important to promote its use in rural India where biomass in form of cow dung, droppings etc is abundantly available. Only the cost barrier may prevent the use of biogas plant. But as the capacity of digester increases the ratio between capacity and cost goes down. So large capacity bio digester based on design of above prototype can be installed in a community to meet their cooking and lighting requirements.

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