Energetic of Family Size Deenbandhu Biogas Plant

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Abstract— Biogas is an easy and healthy cooking fuel. Biogas plants are still made by bricks and masonry material. Now in present, it turns to HDPE/FRP material. Since the development of any energy resource technology, it is necessary to evaluate net production of energy in its useful lifetime. The aim of this study is to describe and estimate the net energy production of family size (1-6 m3) brick masonry material based Deen- bandhu biogas plant. Similar procedure could be applied for pre-fabricated biogas plant to evaluate respective energy yield ratio. This method is a useful tool for approval of any type of biogas plant.

Key words: Biogas Plant, HDPE/FRP material, Deenbandhu biogas plant

I. GENERAL

Biomass is organic matter derived from living organism. Biomass energy has the potential to supply a significant portion of country energy needs while revitalizing rural economies, increasing energy independence, and reducing pollution. About 32% of the total primary energy use in the country is still derived from biomass and more than 70% of the country's population depends upon it for its energy needs. The current availability of biomass in India is estimated at about 500 millions metric tones per year(1).

Traditionally, biomass had been utilized through direct combustion. Cow dung cake is one of the most important and widely used biomass for the production of daily energy needs. It has been estimated that 2.5 billion people around the world are not being able to access the modern fuels. They are highly dependable on locally available wood and cow dung cakes. Burning of biomass or cow dung cakes through direct combustion creates indoor air pollution and ultimately contributing to serious health problems, particularly cancer and respiratory infections. Anaerobic digestion of biomass offers several advantages over direct combustion with several independence, complex sequential and parallel biological reactions, resulting in transformation of organic matter mainly into a mixture of methane and carbon dioxide which is usually referred to as Biogas.

Biogas comprises of 60-65 percent methane (CH_4), 35- 40 percent carbon dioxide (CO_2), 0.5-1.0 per cent hydrogen sulphide (H_2S) and traces of water vapours. It is almost 20 percent lighter than air. Biogas cannot be converted into liquid like liquefied petroleum gas (LPG) under normal temperature and pressure. The slurry coming from digester is rich in nitrogen which is a essential nutrient for plant growth(2).

Biogas is an easy and healthy cooking fuel since methane emissions from untreated cattle dung and biomass wastes can also be avoided. Since there is no pollution from biogas plants, these are one of the most potent tools for mitigating climatic change and being earth saviours.

Application of Biogas technology is increasing everyday in the rural area mainly for cooking purpose that ultimately achieving multiple environmental advantages. Variety of raw material, plant design & field application of biogas technology are available. Among those all, Deenbandhu biogas plant based on cow dung is one of the cheapest than other design and feed stock without sacrificing in biogas production efficiency (Fig.1). Since the development of any energy resource technology, it is necessary to evaluate net production of energy in its useful lifetime. The aim of this study is to describe and estimate the net energy production of family size (1-6 m^3) Deen- bandhu biogas plant.

A. Energetics of a biogas plant

There are several methods for analysing energy yield ratio for biogas plant. Process analysis is one out of them. In the process analysis method (Fig.1.), amount of energy required for construction, operation and maintenance of a biogas plant is determined.

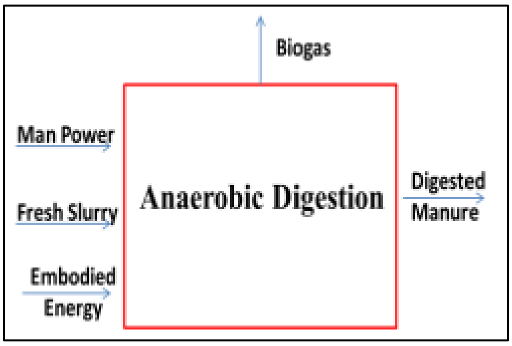

Fig. 1: Overview of Energy analysis of Biogas system

Energy consumed during the production of construction material is calculated with the help of embodied energy per unit material and actual quantity of material used for biogas plant. The actual quantity of material required for construction of family size biogas plant is shown in Table.1. Energy equivalent of human labour is considered as 5MJ/man-day. It is assumed that about half an hour of manual labour is required daily for carrying out routine operation of family size biogas plant. This routine work spends one sixteenth of a standard man day. For a 25 year life time of a biogas plant, a total of 2851MJ of energy is required[3]. The total of energy input to the plant is calculated as-

$$E_{in} = E_D + \sum_j q_i \times E_{ej} \text{.....(1)}$$

where q_j and E_{ej} respectively represent the amount and embodied energy intensity of jth material, and Ed the direct energy input in form of labour and fuel/electricity.

The slurry comes from a biogas plant is used as manure. It is assumed that fertilizer value of digested slurry is remaining same as fresh slurry. Therefore the energy output is only biogas which can be calculated as –

$$E_o = T \times V \times 365 \times \eta_p \times Q_b \text{.....(2)}$$

where the T is the life of the plant i.e. 25 years, η_p is efficiency of annual average gas production i.e. 88%, Q_b is calorific value of biogas i.e. 20MJ/m^3 and V is volume of biogas plant. The energy yield ratio of a biogas plant can be calculated by dividing the results of energy output to input.

B. Outcome:

According to this study, energy yield ratio for family size deenbandhu biogas plant is found much higher than unity (Table.1). Energy yield ratio increases with daily gas production capacity of biogas plant and it sounds economically better in favour to biogas technology (Fig.3.). The results are also compared with the study done by Rubab and Kandpal (1995).

For deenbandhu model, as the capacity of the biogas plant increases, cost of installation, annual operational cost and annual income is increases proportionally where as the payback period remains nearer to 1.4 years for more than 2m^3 meter sized plant (Source: Akshay Urja, February 2016).

Upto December, 2015 with the cumulative total installation of about 48.7 lakh family type biogas plants about 39.58 % of the estimated potential has been harnessed. During the 12th Plan period, about 3.22 lakh plants have been set up. The average estimated biogas generation capacity of these biogas plants is about 6.46 lakh cubic meters per day. These biogas plants are giving an estimated annual savings of about 70.90 lakh numbers of LPG cylinders equivalent and simultaneously producing about 88.4 lakh tonnes of organic enriched bio-manure per year, which is equivalent to about 31,100 tonnes of Urea per annum (Annual report, 2015-16, MNRE, GoI. India).

This study will be helpful in evaluation of any pre-fabricated biogas plant in terms of energy benefit.

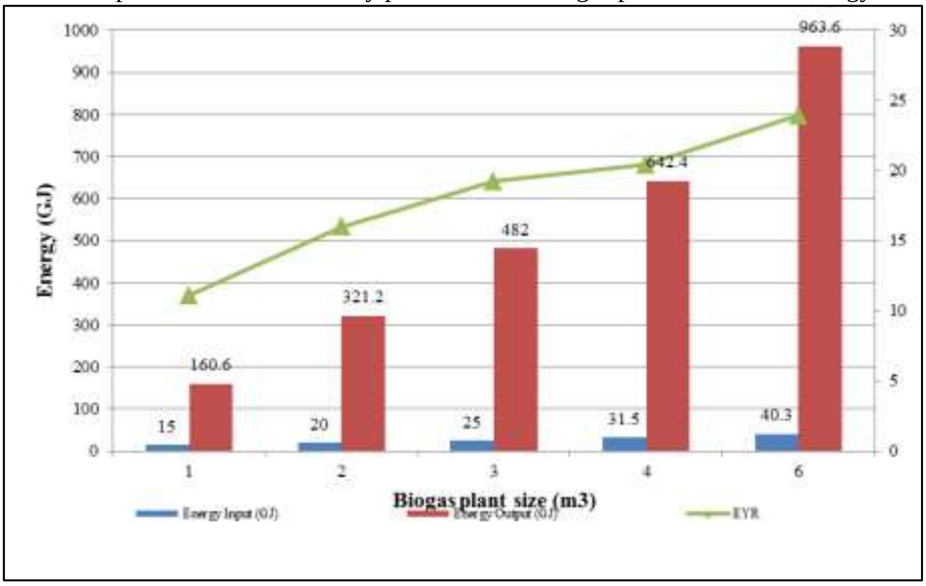

Fig. 2: Energy Yield Ratio of Biogas plant

Material	Unit	Per unit embodied energy intensity (MJ)	1 m^3		2m^3		3m^3		4m^3		6m^3	
			Quantity	E_e	Quantity	E_e	Quantity	E_e	Quantity	E_e	Quantity	E_e
Brick	Nos.	5.9	800	4720	1100	6490	1500	8850	1900	11210	2500	14750
Cement	Bag	305	9	2745	15	4575	19	5795	25	7625	33	10065
Concrete	Cubic meter	1600	1	1600	1.27	2032	1.55	2480	1.98	3168	2.54	4064
Sand	Cubic	990	2	1980	3.5	3465	4.5	4455	6	5940	8	7920

	meter											
GI pipe	Kg.	16.4	1	16.4	1	16.4	1	16.4	1	16.4	1	16.4
PVC pipe	Kg.	77.2	2	154.4	2	154.4	2.3	177.56	2.6	200.72	2.6	200.72
Paint	Kg.	5	1	5	2	10	3	15	4	20	4	20
Subtotal (A)				11220.8		16742.8		21788.96		28180.12		37036.12
Man power (B)	MJ	2851	1	2851	1	2851	1	2851	1	2851	1	2851
Grand total (A+B) Energy Input				14071.8		19593.8		24639.96		31031.12		39887.12
Energy Output				160600		321200		481800		642400		963600
Energy yield ratio				11.41		16.39		19.55		20.70		24.15

Table 1: Total embodied energy for wet type deen-banhu biogas plant

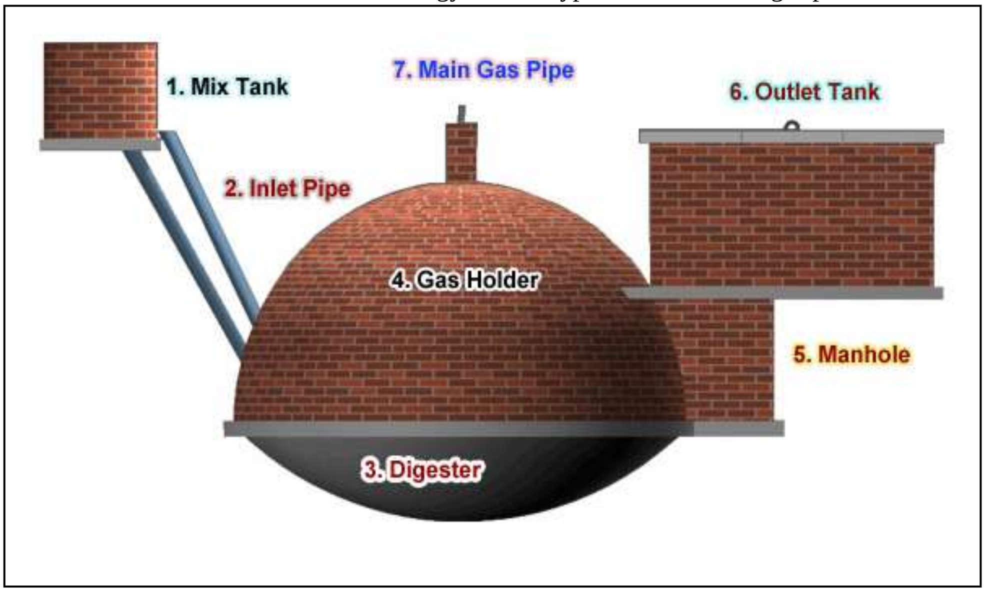

Fig. 3: Components of Deenbandhu biogas plant popular in India

Fig. 4: Construction of Deenbandhu biogas plant

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