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Efficacy of Flexible Balloon Biogas Plant

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Abstract

An attempt had been made to design and develope a flexible balloon stirring digester for anaerobic digestion of JOC. The investigation showed that Jatropha Oil Cake had biogas generation potential of 101.65 litre per kg of dry matter. A stirring device was used to agitate the slurry inside the digester. The methane content of biogas derived from JOC was found to be in the range of 63-68%.

Introduction

Biomass contributes a significant share of global primary energy consumption and its importance is likely to increase in future world energy scenario. Search for ecologically sustainable alternative energy for diesel ended in biodiesel production from vegetable oil, particularly non-edible oil from Jatropha Curcas. The physic nut yields around 0.5 to 12 tonnes of seeds/hectare/year depending on soil and rainfall conditions.

After extracting oil from the seeds the remaining matter that is left behind as byproduct is Jatropha Oil Cake. It can not be directly used as animal feed or not used in agriculture farming because of its toxic nature. Generation of biogas from JOC would be the best solution for its efficient utilization. Biogas production from Jatropha Oil Cake is an interesting option for increasing the energy independence and efficient waste management.

It was observed that the biogas plant, initially charged with pure cattle dung, when gradually replaced with Jatropha oil cake (0-100%), it increased the biogas production up to approximately 25% in reasonable time duration.[2] The daily average biogas production in the rubber-balloon plant was 0.92 m3/d, compared to 1.23 m3/d in the Deenbandhu plant.[3] Silting occurrence was common problem in JOC fed plant for proper biogas generation. To avoid such problem simple and effective stirring arrangement was developed in present study for Flexible Balloon Digester.

Materials and Methods

The balloon digester was fabricated from special three layers reinforced fabric namely high tenacity rubberized nylon fabric coated with hypalon on the outer and neoprene on the inner surface. The plant consisted of a long cylinder made of specially reinforced rubber fabric with inlet and outlet at its extremities. The cylindrical shaped flexible balloon stirring digester was designed by considering the pressure developed inside and other safety factors. To avoid scum formation inside the digester stirring unit was incorporated in the mid-section of balloon digester. The stirring unit consisted of a foot operated Bellow Pump and PVC piping system, with tiny perforations, having 1900 mm length and 30 mm diameter installed at bottom of the digester. The biogas generated in this plant

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was redirected to the piping system with the help of a Bellow Pump. The Bellow Pump sucked the biogas from the secondary gas outlet valve and expeled it back to the stirring section. The redirected gas enters into the perforated section causing bubbles inside the digester while leaving through the tiny perforations. These raising biogas bubbles provided a gentle mixing of the substrate and checked the formation of scum layer inside the digester, thereby maintained a healthy microbial activity in the digester.

The pre-soaking of Jatropha Oil Cake was done before feeding it in the plant. There was a tendency of deoiled cake to absorb more water during presoaking. Hence there was a more requirement of water for the plant comparatively the cattle dung based biogas plants. Initially deoiled cake mixed with water in 1:2 ratio was kept in presoaked condition for 24 hours. This was performed by keeping the mixture of deoiled cake and water in the mixing tank for same time and later the presoaked cake was again mixed in the mixing tank with remaining amount of water at the time of feeding. The substrate such formed was allowed to flow from the mixing tank to the digester daily.

The experiment was conducted at ambient temperature. The daily biogas produced from

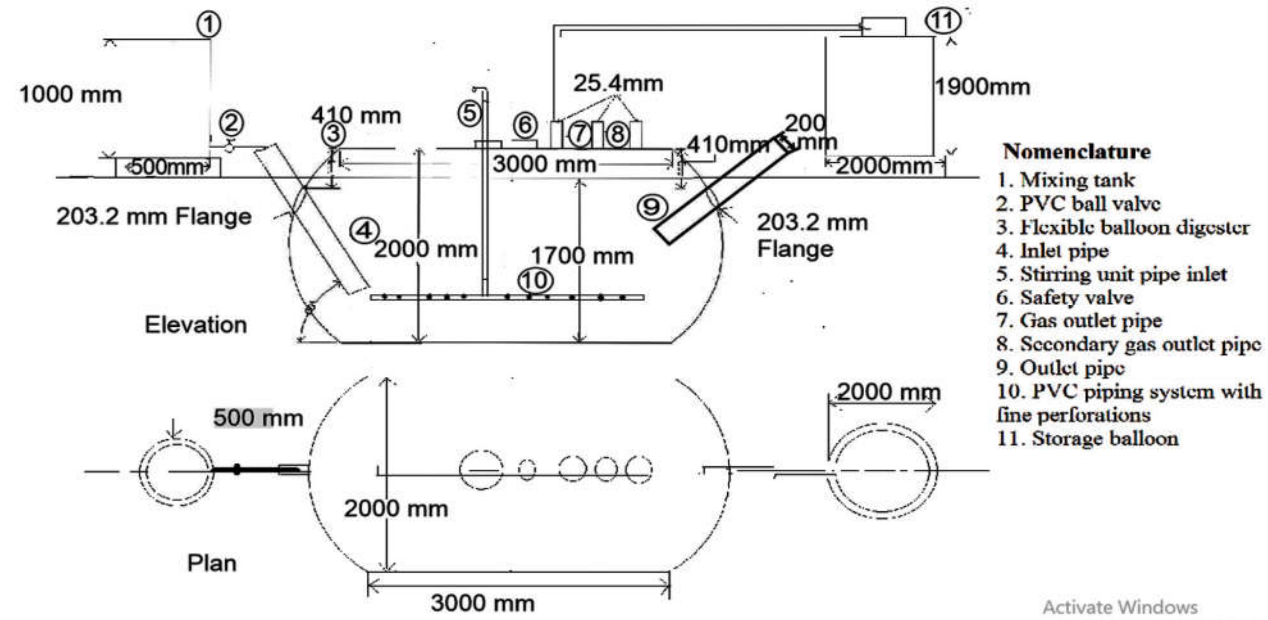

Fig.1: Schematic diagram of Flexible Balloon Biogas Digester of 6 cum capacity.

Fig. 2 : Flexible Balloon Stirring Digester at field (6 Cubic metre).

Jatropha Oil Cake based Flexible Balloon Biogas Plant in field experiments was estimated by GALLUS 2000 (EL-05) Dry Gas Flow Meter. Also daily methane and carbon dioxide contents of generated biogas were analyzed using a GASBOARD- 3200P portable Biogas Analyzer.

The biogas produced from this plant was stored in storage balloon. That stored biogas was used for testing engine performance for power generation and for cooking purposes. The schematic illustration of FBSD is given in Figure 1 and Figure 2.

Results and Discussion

FBSD specifications and design parameters of the present study was summarized in Table 1.

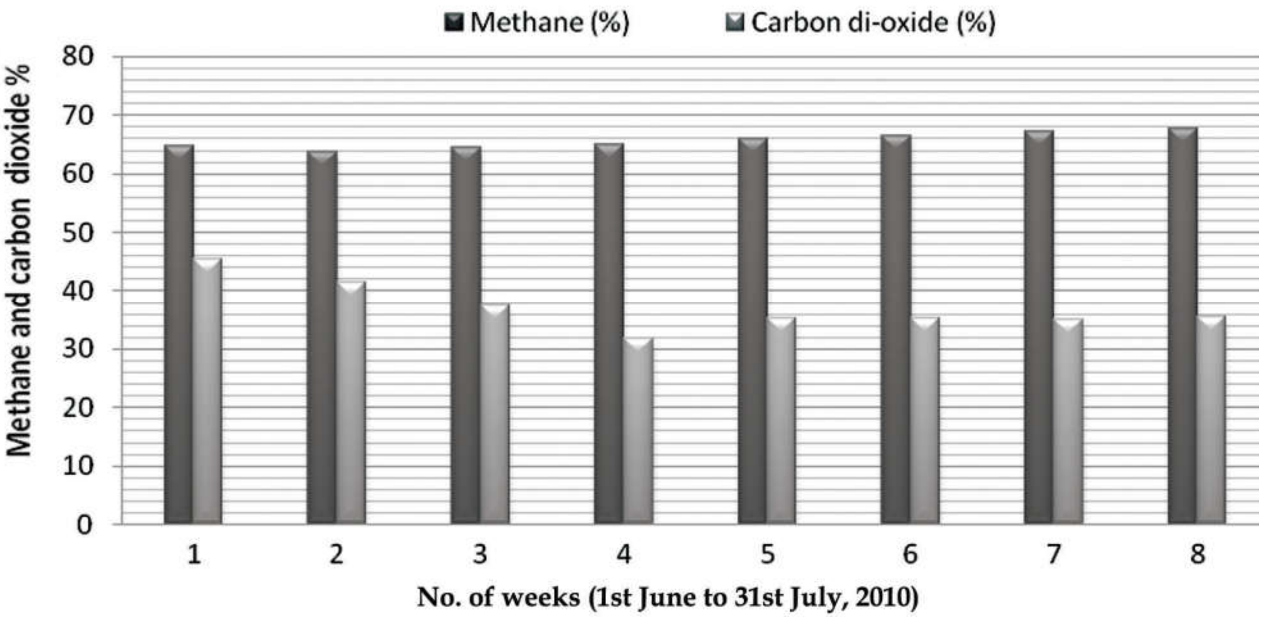

Fig. 3 : Weekly average methane and carbon dioxide content in 8 weeks period.

Table 1: FBSD specifications and design parameters.

(A) FBSD Specifications		
1	Plant capacity (m^3)	6
2	Total volume of digester (m^3)	9.4
3	Biogas storage balloon capacity(m^3)	6
4	Retention period (days)	40
5	Diameter of the balloon digester (mm)	2000
6	Length of the balloon digester (mm)	3000
7	Dimensions of pit (mm)	3100 x 2000 x 1100
8	Dimensions of mixing tank (mm)	1000 x 500
9	Dimensions of biogas storage balloon (mm)	2000 x 1900
9	Capacity of Foot Bellow pump (litre)	2.00
10	Earth pressure (Pa)	1428
11	Thickness of the balloon digester (mm)	0.8
(B) Stress, Strain and Dimensional variations in Balloon Digester		
i	Hydrostatic pressure	21991.2 Pa
ii	Hoop stress ($\sigma\theta$)	37.96 MPa
iii	Longitudinal stress (σL)	18.98 MPa
iv	Circumferential strain	10.84 X 10^{-3}
v	Longitudinal strain (εL)	1.06 X 10^{-3}
vi	Change in diameter	21.7 mm
vii	Change in length	10.9 mm

Daily methane and carbon dioxide content of generated biogas was analyzed using a GASBOARD – 3200P portable Biogas Analyzer. The average methane content of produced biogas was 65.23 per cent whereas the average carbon dioxide content was 33.11 per cent in 8 weeks period. Weekly average methane and Carbon dioxide content from JOC was shown in Fig. 3.

At every 20 days interval the N, P, K content of the fresh JOC slurry and digested slurry was observed. Significant differences in N, P, K content of biogas spent sludge and the fresh slurry was found. The average nitrogen, phosphorus and potassium content of the fresh slurry were 3.05, 1.95, and 1.28 respectively whereas in the digested slurry it was 3.83, 2.16, and 1.54 respectively.

Conclusions

The average gas production was 190.68 l/kg dm with average methane content of 65.23 per cent. The stirring unit was used for avoiding the formation of scum layer inside the digester throughout the period of operation.

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