Development of Jatropha Oil Cake Based Flexible Balloon Biogas Plant Coupled with Stirring Device

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Abstract

Jatropha Oil Cake (JOC) based Flexible Balloon Stirring Digester (FBSD) of 6 cum capacity was designed and installed at Gopal Pura (Bhindar) near Udaipur under Public – Private – Project mode. The present 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%.

Keywords: Balloon digester; Jatropha Oil Cake; Anaerobic digestion; Biogas.

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. It is commonly known as pysic nut or purging nut. The physic nut yields around 0.5 to 12 tonnes of seeds/hectare/year depending on soil and rainfall conditions (Dhanya M.S. *et al* 2009). The oil content in Jatropha seed varies from 31 to 37%. 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 (Nafisa Ali, *et al* 2010). Rubber-balloon biogas plant of 2-m^3 capacity was developed under hilly conditions and compared with a fixed-dome type Deenbandhu biogas plant of the same capacity. The daily average biogas production in the rubber-balloon plant was 0.92 m^3/d, compared to 1.23 m^3/d in the Deenbandhu plant (Kanwar S.S. and Guleri R.L., 1994).

The laboratory experiment for the biomethanation potential of dried and powdered Jatropha cake along with buffalo dung at 6% total solids was carried out. The experiment was run on daily feeding basis in five litre capacity glass digesters for 180 days. Results showed significantly

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higher (139.20%) biogas production in test (Jatropha cake + Buffalo dung) over control (Buffalo dung only) digesters with methane content of 71.74% (Shilpkar Pratik 2009).

Materials and Methods

Flexible balloon stirring digester was designed for anaerobic digestion of Jatropha Oil Cake and was installed at Gopal Pura village (Bhindar) about 55 km away from Udaipur. This project was taken under Public – Private – Partnership and Green Oil Energy Sciences (GOES), New Delhi based company working in biodiesel production provided the financial assistance for this project. 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 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 experiment was conducted at ambient temperature. The daily biogas produced from 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.

Results and Discussion

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

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		
	Hydrostatic pressure	21991.2 Pa
	Hoop stress (σθ)	37.96 MPa
	Longitudinal stress (σL)	18.98 MPa
	Circumferential strain	10.84 X 10-3
	Longitudinal strain (εL)	1.06 X 10-3
	Change in diameter	21.7 mm
	Change in length	10.9 mm

Biogas volume generated through anaerobic digestion of JOC was observed daily starting from 1st June, 2010 to 31st July, 2010 by GALLUS 2000 (EL-05) Dry Gas Flow Meter. Average biogas volume generated through this plant was 190.68 lit/kg dm and average dry biogas volume produced at STP was 145 lit/kg in 8 weeks period. Weekly average biogas production in 8 weeks period was shown in Figure 1.

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 Figure 2.

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

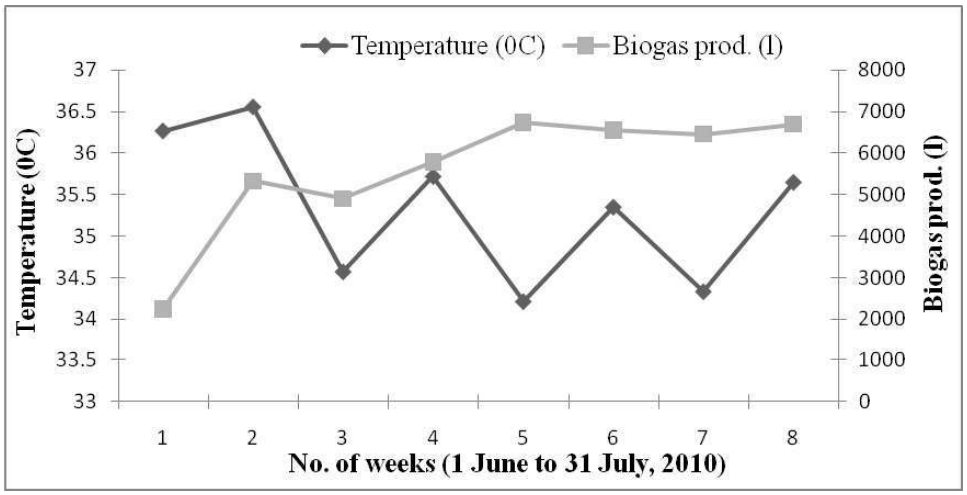

Fig. 1: Weekly average biogas production (l) in 8 weeks period

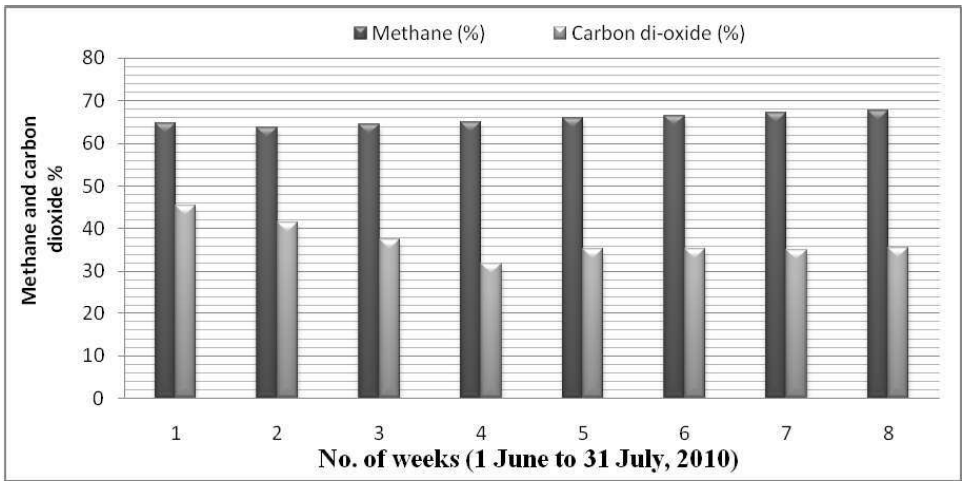

Fig. 2: Weekly average methane and carbon dioxide content in 8 weeks period

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.

Conclusion

The average gas production was 190.68 l/kg dm with average methane content of 65.23 per cent. Biogas production from Jatropha Oil Cake can be an interesting option for increasing the energy independence and efficient waste management.

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