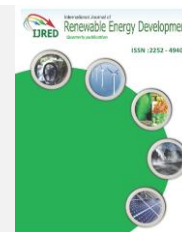




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Biogas Filter Based on Local Natural Zeolite Materials

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ABSTRACT: UPT BPPTK LIPI has created a biogas filter tool to improve the purity of methane in the biogas. The device shaped cylindrical tube containing absorbent materials which based on local natural zeolite of Indonesia. The absorbent has been activated and modified with other materials. This absorbtion material has multi-adsorption capacity for almost impurities gas of biogas. The biogas filter increase methane content of biogas for 5-20%. The biogas filter improve the biogas's performance such as increasing methane contents, increasing heating value, reduction of odors, reduction of corrosion potential, increasing the efficiency and stability of the generator.

Keywords: biogas, biogas filter, electric conversion, local natural zeolite, methane concentration

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1. Introduction

Indonesia is very rich with agricultural resources, where livestock is one of these resources. Beside as a food resource, the livestock also an energy source by converting livestock dung into biogas. Biogas is made by feeding cow dung into the digester tank through the input pipe. The fermentation process is influenced by several factors such as anaerobic conditions, substrate, pH, temperature, agitation, moisture content, solids concentration, C/N ratio, toxic materials, and length of fermentation substrate in the digester (Bughiarello *et al.* 1981; Tahir & Mustafa 2007). The main composition of biogas is methane (CH₄) of 40-75%. Whereas the most impurities gas is carbon dioxide (CO₂) and another impurities gas are hydrogen sulfide (H₂S), water vapor (H₂O), nitrogen (N₂), hydrogen (H₂) and oxygen (O₂) (Monnet 2003; Muryanto 2006; Hambali 2007). If the methane content of biogas is under 60%, biogas use as cooking fuel only and hardly convert into electricity (Febrisiantosa & Julendra 2008). Therefore, tools or

methods to increase methane content in biogas by reduce impurities gas was needed.

UPT BPPTK LIPI has improved a biogas filter tool or method to increase the purity of methane in the biogas based on local natural zeolite. Biogas purification is conducted by adsorption system using activated zeolite as an adsorbent. One of the natural zeolite deposits in Indonesia, which has a fairly large in amount (55,000,000 m³) with silica content approximately of 60%, is the local natural zeolite of Gunungkidul – Yogyakarta. These minerals often found in the hills area of Baturagung, Gedangsari District (Hargomulyo, Watugajah, Mertelu, and Tegalrejo Village) and Ngawen District (Tancep Village) (PEMKAB GUNUNG KIDUL 2013).

Zeolite structure performs adsorption and absorption of the compound H₂O, CO₂, SO₂, H₂S (Weitkamp & Puppe 1999), with the gases absorption ability of zeolite is up to 25% (Sutarti & Rachmawati 1994). Zeolite control the main cause greenhouse effect gases of CO₂ and N₂O, except CH₄ (Delahay & Coq 2002). Zeolite is able to absorb the main impurity gases of

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water vapor (H_2O), CO_2 and H_2S , not absorb the main gas of CH_4 (Wahono *et al.* 2008).

Optimization of the natural zeolite performance is conducted through the activation stage. Natural zeolite is activated by heating (calcination) to evaporate the trapped water in the pores of zeolite crystals, so the surface area was increased (Sutarti & Rachmawati 1994). In addition, zeolite is activated through dealumination process using acid solution. It was able to increase the surface area and pore volume, to reduce the mean pore spokes, to improve the ratio of Si/Al and acidity of natural zeolite (Windarti 2002). After dealumination and calcination, natural zeolite Gunungkidul is better than the previous with higher SiO_2/Al_2O_3 ratio (Widayat *et al.* 2008). This paper report the results of the biogas filter application based on local natural zeolite as an effort to improve the performance of biogas.

2. Materials and Methods

2.1 Biogas Filter Preparation

Cylindrical tube device contain absorbent which based on local natural zeolite of Indonesia. The device was connected to biogas digester as a biogas filter and shown in Figure 1. The absorption material was activated and modified with another local natural material. Gunungkidul natural zeolite were crushed to 100 mesh size, dealuminated with HCl for 24 hours, formed pellets with local kaolin Gunungkidul modification and calcined at $400\text{ }^\circ\text{C}$ for 4 hours. Ratio of local kaolin : aquadest : local zeolite was 1 : 3 : 6 in weight (Wahono *et al.* 2010).

2.2 Biogas Filter Trial

The biogas filter trials were conducted at some biogas installation locations and some types of generator capacity (1 HP, 3 HP, 9 HP). In these trials were observed one or several parameters such as increasing methane content, cooking time, the colour of fire, electrical parameter, etc.

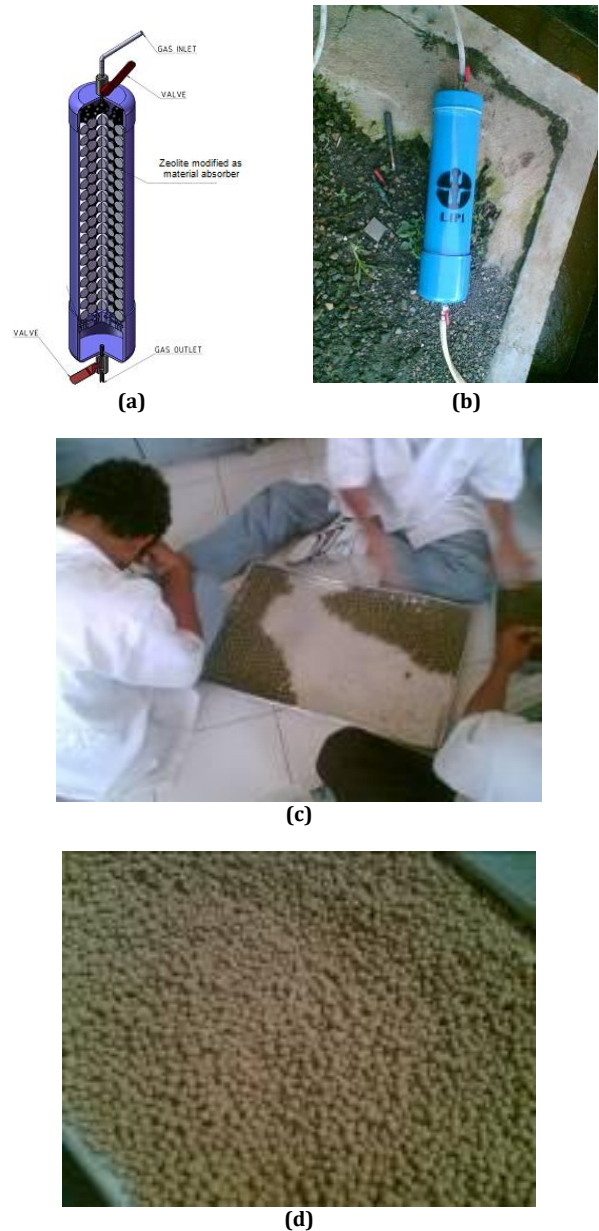


Fig. 1 The biogas filter : (a) Diagram; (b) Cylindrical tube; (c) Zeolite modification process; (d) Modified natural zeolite



(a)



(b)

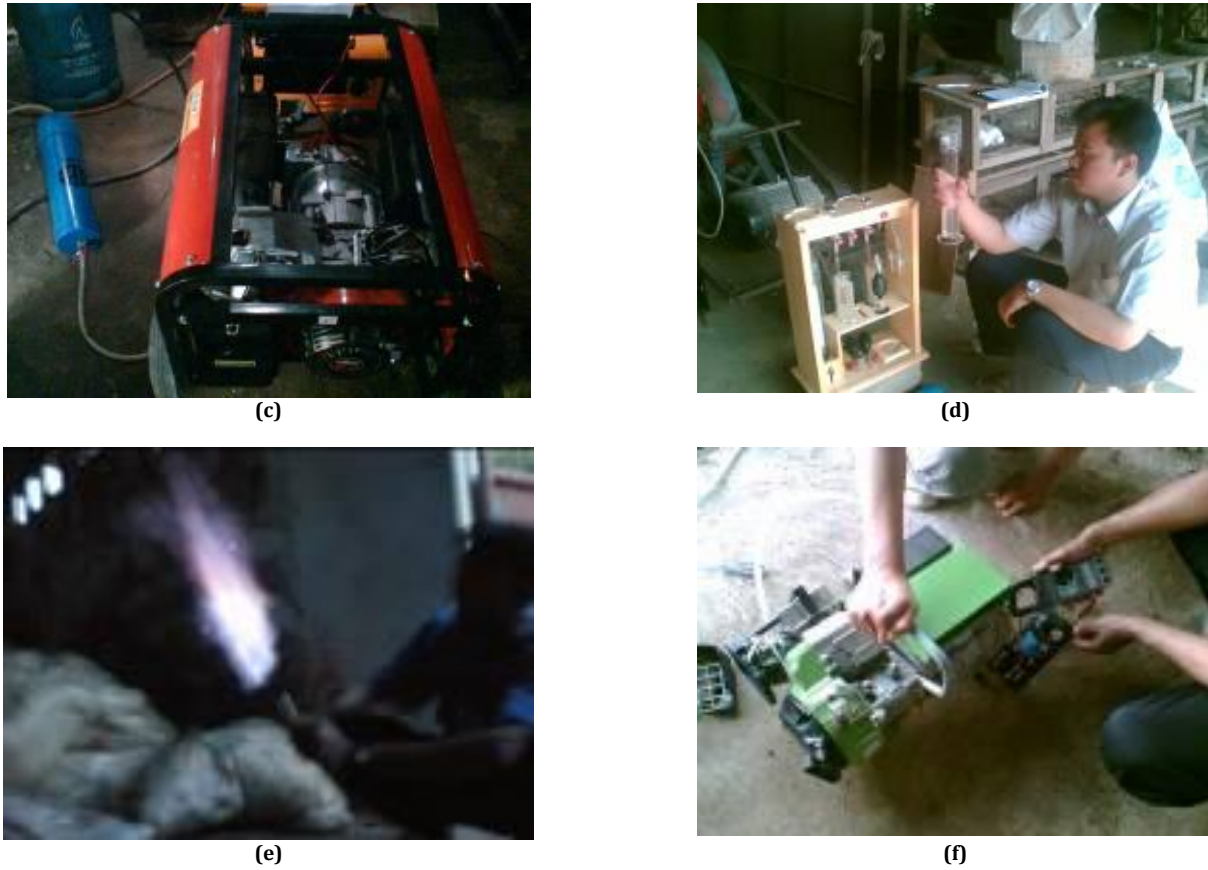


Fig. 2 The biogas filter trials, application and observation : (a) Application on 1 HP generator; (b) Application on 3 HP generator; (c) Application on 9 HP generator; (d) Gases Analysis (Orsat and GC); (e) Flame color observation; (f) Electrical observation

3. Result and Discussion

Trials and observations activities of biogas filter were shown at Fig. 2. The trials observe some parameters such as methane analysis using Gas Chromatography, gas analysis using Orsat method, flame color observations, cooking time and electrical parameters observations (electric current and voltage) on the generator applications.

Table 1
The results of biogas purification by alkaline solution and / or zeolite (Wahono et al. 2008)

Absorber of impurities gas	Location of biogas installation	Methane content of biogas (%)		
		Before	After	Increase
KOH Solution	Gading-Playen	62,5	77,4	14,9
	Bandung-Playen	63,1	68,6	5,5
	Kepek-Wonosari	64,1	72,3	8,2
KOH Solution – Nat. Zeolite Hybrid	Gading-Playen	73,3	97,3	24,0
Synthetic Zeolite	Gading-Playen	75,2	93,2	15,0
Nat. Zeolite Modif. 1	Gading-Playen	63,4	70,1	6,7
Nat. Zeolite Modif. 2/The biogas filter	Gading-Playen	61,2	81,7	20,5

In the early of biogas filter development, the comparison with another biogas purification methods were conducted. It use absorbtion methods such as using alkaline solutions and synthetic zeolites. Methane content was determined by Gas Chromatography of PT Petrolab Service Jakarta which shown in Table 1.

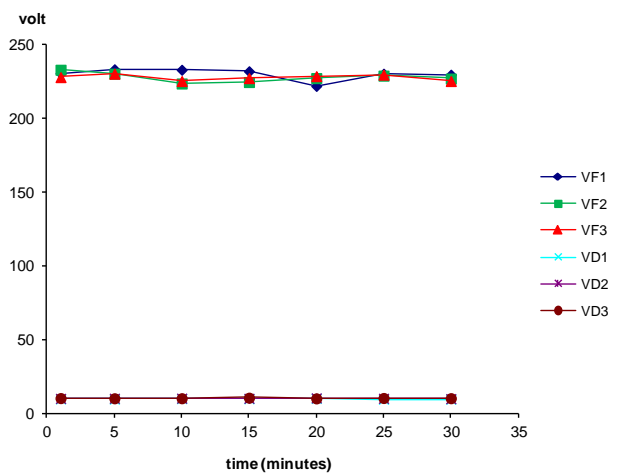


Fig. 3 Graphic of voltage vs time for using (VF) and without (VD) the biogas filter (Wahono et al. 2009)

Table 2
The data of electric properties generator using the biogas filter (Wahono *et al.* 2009)

Data	Time (minute)							Range
	1	5	10	15	20	25	30	
V _{avg} (Volt)	231	234	233	232	222	231	230	222 – 234
	233	231	224	225	228	229	227	
	228	231	226	228	229	230	226	
A _{avg} (Ampere)	1,27	1,27	1,27	1,33	1,30	1,30	1,37	1,07 – 1,37
	1,27	1,27	1,07	1,27	1,33	1,27	1,23	
	1,27	1,27	1,27	1,20	1,27	1,27	1,27	
P _{avg} (Watt)	293	296	296	310	289	300	314	239 – 310
	296	292	239	285	304	290	280	
	289	292	286	273	290	291	286	

Note : V = voltage; A = current; P = power; avg = average

Table 3
The biogas filter utilization at UPT Kapitan Meo, Belu-NTT (Wahono *et al.* 2009)

Properties	Without the biogas filter	Using the biogas filter	Increase performance
Cooking time of 200 cc water	312 seconds	260 seconds	52 seconds (16,7%), increase heating value
Flame color observation	Blue with yellow-red impurities	Clean blue	More perfectly combustion, so reduce soot
Generator test	OK	OK	Corrosion potential reduction
Methane content	40,78 %	46,05 %	5,27 %

Based on Table 1, the highest result was obtained by purifying of KOH solution - Natural Zeolite Hybrid. However, utilization of alkaline solution was less effective relatively due to quickly saturated. Therefore, zeolite material was used for the further development, especially for the natural zeolite modification 2 as the second highest methane content difference.

Electrical parameter data were taken from the biogas filter application using generator (1 HP). They are electric current and voltage value which determined by ampere – volt meter when connected to hand grinder machine (670 W). The data of electric voltage between using the biogas filter (VF1, VF2, VF3) and without the biogas filter (VD1, VD2, VD3) were shown at Figure 3. It show that there is significant different in voltage and significant effect for application in electric equipment. The machine unactivate (9-11 V) without the biogas filter, but the machine work correctly (222 – 234 V) when using the biogas filter. It was happened due to utilization of biogas filter resulting higher methane content on biogas. In addition, data of Table 2 show that generator electric parameter was in stable condition.

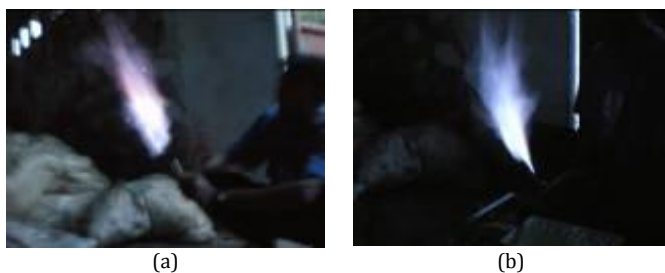


Fig. 4 Flame color observation : (a) Without the biogas filter; (b) Using the biogas filter

Some biogas filter observations were conducted at biogas plant in UPT Kapitan Meo, Belu – NTT. The observations were cooking time, flame color, generators test, and methane contents which shown in Table 3 and Figure 4. The biogas filter improve the performance and quality of biogas. In addition, the presence of the biogas filter reduces corrosion potential on engine generator due to acid (H₂S) and water vapor was reduced.

Based on some trials, tests and observations, it was concluded that the biogas filters increase methane content of biogas about 5-20%, increase heating value, reduce odors (reduce H₂S), increase energy conversion efficiency and stability of generator (conversion energy into electricity), and reduce the corrosion potential for the engine. The biogas purification efforts were part of safely alternative energy storage solutions for biogas by converting into electricity which shown in the diagram of Fig. 5.

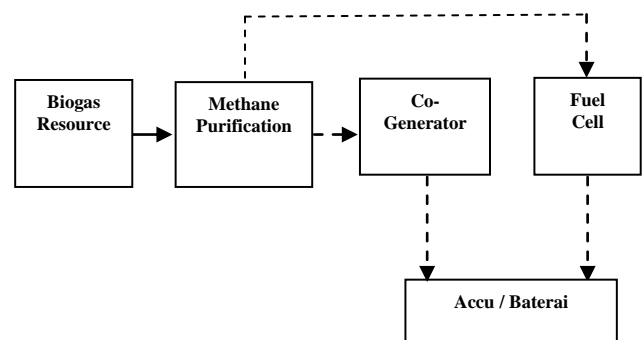


Fig. 5 The diagram of biogas energy storage as electricity using co-generator and fuel cell (Wahono 2007)

4. Conclusion

The biogas filter, based on modified local natural zeolite, improve the performance of biogas such as increasing methane contents, increasing heating value, reduction of odors, reduction of corrosion potential, increasing the efficiency and stability of the generator. On the other hand, this material is able to develop/ use for further purification of various pollutant gases such as in the chimney of factory, the motor vehicles and others.

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