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Municipal Solid Waste Treatment Using Plasma Gasification with the Potential Production of Synthesis Gas (Syngas)

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Abstract: This research was conducted for the purpose to overcome Indonesia waste problem. The samples are classified into garden waste, paper waste, wood, food waste, and MSW with objective to identify which type of waste give out more syngas since there is waste separation in Indonesia. All samples were treated by plasma gasification without pre-treatment (drying). Arc plasma torch used in this experiment was made by National Nuclear Energy Agency (BATAN) and used Argon as the gas source. Then the torch was connected to self-designed gasification chamber and gas washing system before injected into a gas bas for composition analysis. Another objective is to identify factors that may affect the gasification efficiency and the experiment shows that moisture content is not really affecting the efficiency but the duration of the process. The mass reduction of each samples were recorded, then the gas produced from the gasification process were analyzed. The result shows that food has the highest mass percentage reduced and producing the highest amount of hydrogen amongst other samples. However, treating MSW also produce considerably high amount of hydrogen. In conclusion, MSW direct treatment (without separation) using plasma gasification is feasible since it still produces desirable quality of syngas.

Keywords: MSW gasification, plasma gasification, arc plasma sintering, waste treatment in Indonesia.

1. Introduction

Indonesia is currently in a state of waste emergency [1] because there are so many problems with the waste management and it hardly copes with the population growth. Landfill is popularly used due to its low maintenance cost. By far, 69% of the waste in Indonesia goes to landfill. The main problem in Indonesia is that the final disposal sites (known as *Tempat Pembuangan Akhir* or TPA) are poorly designed and not working effectively in Indonesia since it is merely an open disposal sites which may result in groundwater, air and soil pollution to the surrounding area [2]. All types of waste are mixed together since there are no regulations for household waste separation yet in Indonesia. The government is currently building the first waste incineration in Jakarta with a capacity to thermally process 2,000 tons of waste daily. However, there are 7,000 tons of waste generated daily in Jakarta. Therefore, incineration still could not overcome the waste problem.

A search for other option comes to plasma gasification. Plasma waste treatment to energy itself is not a new technology and the power plant has been operated in developed countries but not yet in Indonesia. The quality of syngas produced is affected by the waste composition. Thus, the compositions vary between countries since it is influenced by culture, economic development, climate, and energy sources [3]. Therefore, this research will focus on waste composition in Indonesia with laboratory scale plasma torch created by *BATAN* for the gasification process.

2. Research Method

2.1. Sampling Method

MSW is a mixture between organic and non-organic waste (MSW), the sample will be simulated based on the municipal solid waste composition in Indonesia since the sample taken is relatively small and therefore random sampling directly from the dumping site is inefficient due to the unequal component distribution in each samples. Different types of organic waste were measured individually with purpose of identifying which types of organic gives out better quality of syngas but not for the inorganic waste since it is not carbon based.

All samples were simulated. MSW were simulated based on Jakarta Waste Composition in 2013 [4] The waste composition used in this experiment were:

Table 1. Composition of Waste Samples

No.	Waste Type	Sample Weight (g)	Composition
1	Garden	150	50 gr branches 50 gr leaves 50 gr soil
2	Paper	100	25 gr white paper 25 gr magazine 25 gr newspaper 25 gr cardboard
3	Wood	100	35 gr leftover rice 166 gr fruit peels 24 nutshells 36 gr egg shells 39 gr vegetable scraps 50 gr meat and bone scraps
4	Food	350	35 gr leftover rice 166 gr fruit peels 24 nutshells 36 gr egg shells 39 gr vegetable scraps 50 gr meat and bone scraps
5	Municipal Solid Waste (MSW)	350	15 gr leftover rice 56 gr fruit peels 23 gr nutshells 12 gr egg shells 55 gr vegetable scraps 17 gr meat and bone scraps 24 gr wood beam 8.5 gr saw dust 10 gr soil 6 gr cardboard 15 gr newspaper 6 gr plastic bags 29 gr food packaging 31.5 gr broken glass 28 gr aluminum foil 7 gr rubber band 7 gr cloth

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2.2. Design of experiment

The schematic diagram of the overall experiment setupis shown in Fig.1. and the specification of gasification chamber design shown in Fig. 2. The material used for the chamber were 2mm thick stainless steel cylinder.

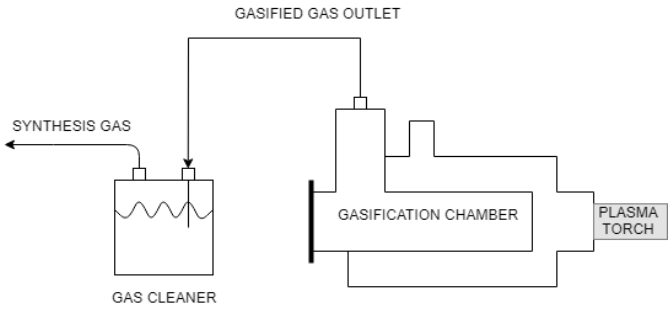

Figure 1. Experiment Setup

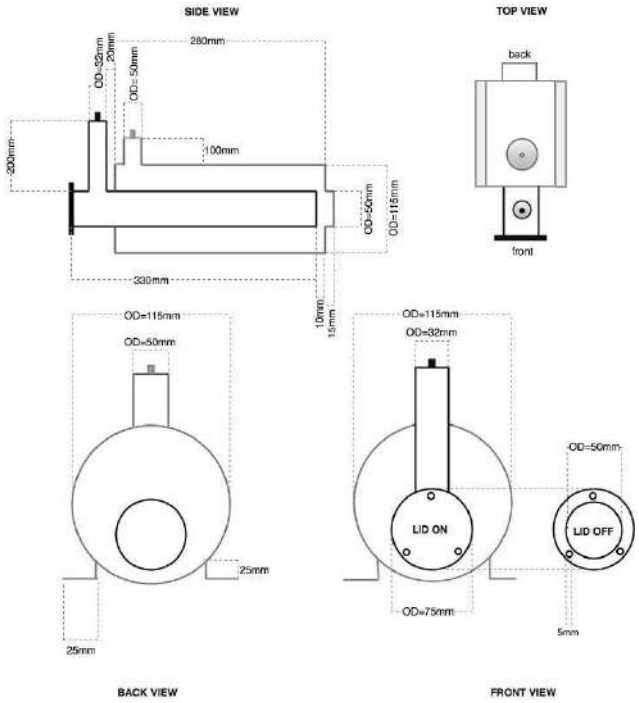

Figure 2. Gasification Chamber Design

Each sample were fed into the gasification chamber (Fig.2) and the weight reduced were measured. The gas produced during the gasification process were injected into a gas sampling bag for further composition analysis using Gas Chromatography – Thermal Conductivity Detector (GC-TCD).

3. Results and Discussion

The result from GC-TCD shows that food produce the highest amount of hydrogen, followed by wood, MSW, garden, and paper (Fig. 3). The gasification efficiency of each type of waste shown in Table 2. Food has the highest mass reduction after the gasification process. However, it has no direct correlation to the gasification efficiency but to the duration of gasification, in which increase the electricity consumption for the process and lower the efficiency. Gasification efficiency and quality of syngas produced is still highly affected by the waste composition.

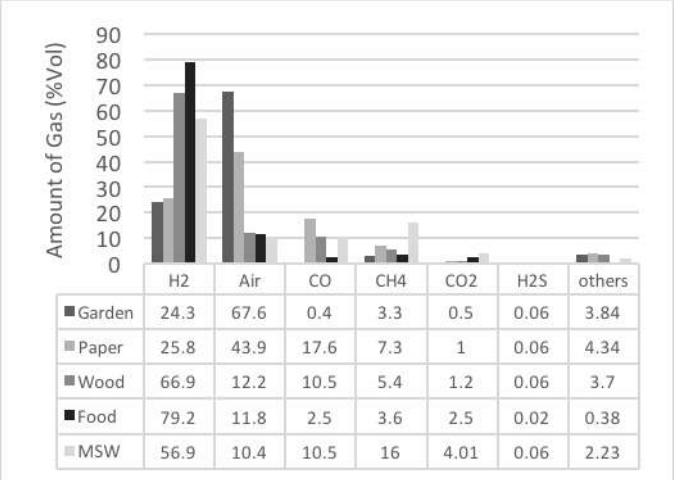

Figure 3. Gas Analysis Result (GC-TCD)

Table 2. Correlation between mass reduction and gasification efficiency

No.	Waste Type	Gasification Efficiency (%)	Mass Reduced (%)	Gasification Time (h)
1	Garden	17.38	74.7	18.57
2	Paper	30.02	75.8	15.94
3	Wood	33.82	78.8	20.83
4	Food	18.4	87.8	47.8
5	MSW	29.22	58.3	39.15

Plasma gasification for waste treatment has proven to be a good alternative to the current landfills and incineration as it could reduce 50% of the waste weight. This would be very helpful in reducing the amount of waste in Jakarta since it is already exceeding the landfill capacity. In addition, the syngas produced during the gasification process of the waste proven to have a good quality as it has a high proportion of hydrogen and also with the presence of carbon monoxide and methane

Factors that may affect the treatment using plasma gasification are moisture content. It was unwanted because it affects greatly to the duration of plasma gasification, which makes the process longer resulting in higher energy consumption to operate the plasma. The plasma is operated with 12V and 80A, which equals to 960 watt or 0.94kWh. Electricity consumption by each sample were shown in Table 4.6.

Table 3. Energy Efficiency of Syngas

	Plasma Operation Time (h)	Electricity Consumption (kWh)	Gas Volume (m^3)	LHV Syngas (KJ/m^3)	Energy from Syngas (kWh)
Garden	0.310	0.297	2.834	13763.12	10.83
Paper	0.266	0.255	2.720	14823.66	11.19
Wood	0.347	0.333	3.466	12585.39	12.11
Food	0.797	0.765	2.747	11886.98	9.069
MSW	0.653	0.626	3.806	15748.07	16.64

Comparing the energy of the syngas and the electricity consumption, it could be concluded that the energy conversion is very efficient. However, in plasma gasification power plant, gas cleaning, gas

cooling, and gas purification is required before syngas could be commercially used. All those treatments will certainly increase the energy consumption used to produce the syngas itself.

4. Conclusion

Plasma gasification for waste treatment is applicable in Indonesia. Though food produced highest amount of hydrogen, MSW still produces considerably good amount as well. Which means the waste could be directly treated without being separated. The gasification efficiency is still low due to high moisture content of the sample but could be improved by adding drying to the pre-treatment.

References

[1] Jong, H. N. (2015, October 9). *Indonesia in state of waste emergency.* Retrieved November 19, 2017, from The Jakarta Post: http://www.thejakartapost.com/news/2015/10/09/indonesia-state-waste-emergency.html

[2] Sholichin, M. (2012). Field Investigation of Groundwater Contamination from Solid Waste Landfill in Malang , Indonesia. *International Journal of Civil & Environmental Engineering IJCEE-IJENS , 12*, 74-81.

[3] The World Bank. (2012). *URBAN DEVELOPMENT SERIES – KNOWLEDGE PAPERS*. Retrieved January 16, 2018, from What a Waste : A Global Review of Solid Waste Management: http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/Chap5.pdf

[4] Aprilia, A., Tetzuka, T., & Spaargaren, G. (2013). The 3 rd International Conference on Sustainable Future for Human Security Inorganic and hazardous solid waste management : Current status and challenges for Indonesia. *Procedia Environmental Sciences , 17* (81), 640-647.