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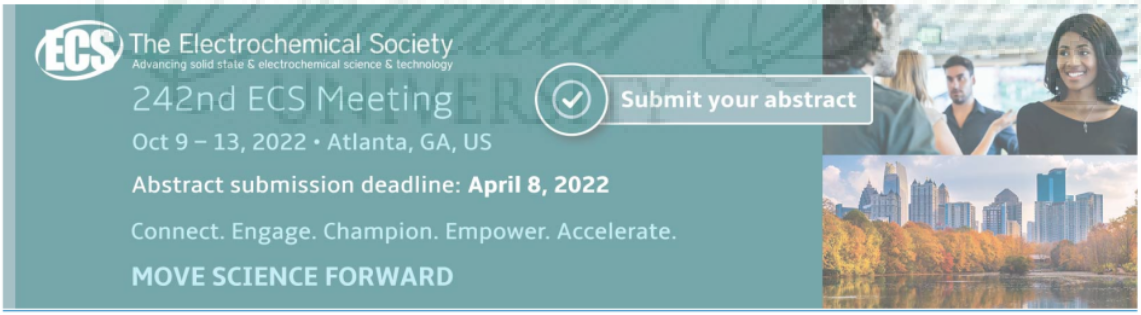

An experimental study of liquid smoke and charcoal production from coconut shell by using a stove of indirect burning type

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Abstract. The quality of liquid smoke and charcoal product yield can be improved by conducting pyrolysis process through indirect heating process. However, a great huge of energy is required to reach the exact operating temperature. In this experiment, slow pyrolysis of coconut shell is performed for liquid smoke and charcoal production using indirect method where the feedstock is just heated in a tube by using LPG as the heat source. The effect of feedstock size and the operating temperature on the liquid smoke and charcoal yields are investigated by varying the coconut shell sizes in the ranges of 1 to 7 cm^2, while the operating temperature is expected as low as possible to reduce the energy required. The optimum process conditions for maximizing the two products yields and quality were also identified to meet the user requirement. The various characteristics of liquid smoke obtained under the optimum conditions for maximum yield are identified based on standard test methods. Data from a simple way of charcoal and liquid smoke production during preliminary research of this study indicated that the coconut shell sizes, and the operating temperatures are the crucial parameter during process.

1. Introduction

Coconut shell is one of typical biomass waste which is found abundant in most of the tropical countries including Indonesia. Liquid smoke and charcoal which termed as bioenergy are a very useful product that can be obtained from coconut shell. A primitive stove, where the biomass is burnt directly is a very old oven used to generate charcoal and liquid smoke. The charcoal can be utilized as solid fuel due to the high calorific value of about 23.68 MJ/kg in it [1], whereas the liquid smoke can also be used as an organic fertilizer instead of synthetic fertilizer at agricultural area [2]. Research revealed that an excessive use of synthetic pesticides causes serious environmental pollution as well [3] [4]. The way on biomass processing to produce bioenergy can be summarized in three main routes; pyrolysis, gasification and combustion [5] [6]. Pyrolysis is a process in the absence of oxygen aimed to produce useful and valuable of bio-liquid, solid char and flammable gases. Conventional slow pyrolysis can be implemented to produce liquid smoke from coconut shell with the parameters considered are the reactor temperature, coconut shell sizes and the reactor heating rate.

Solid char and liquid smoke product quality obtained via pyrolysis were reported earlier. The present results showed beside being able to be converted as ethanol [7]. However, these products quality are quite difference depending on the operating parameters used especially the heating method. For an optimum product purposes, high heating rates is highly required during degradation of the coconut shell to the useful product [8]. However, to achieve this in commercial purposes is not practicable or necessary. Few researches have been proved that the smoke liquid quality also depend on the coconut shell characteristic and the stoves type used [9]. Other reported that the products depend thoroughly on the operating temperature [10] [11]. Until now, lots of the research is focused on the small particle sizes of coconut shell as the main parameter on producing optimum product due to the excellent heat transfer on it. For example, with the particle size ranges from 1.18 – 1.80 mm, Sundaram et. al [12] gained an optimum yield of pyrolysis liquid about 38-44 wt%. However, small particle size is usually ignored when the production activity at the farm location.

A local agricultural community found near the research location used liquid smoke as fertilizer. The necessity of liquid smoke and charcoal were generated regardless to the size of the feed material. The sizes of feed become less important as long as the required product still can be obtained with low cost. Figure. 1 shows a traditional stove production of charcoal at the farmer area is carried out regardless to the size of the coconut shell. Raw material of coconut shell residue is collected, naturally drained, utilize a very simple stove with direct burning method was performed, the raw coconut shell is fed into the stove and burnt slowly until the charcoal of low grade is gained. The smoke is usually sacrifice freely into the atmosphere. This smoke is a valuable residue of process which can be condensed into liquid form instead of released to the atmosphere.

Air pollution in Indonesia becomes serious problem that must be considered. The increasing environmental impact related to climate change and global warming, which is mainly the result of the escalating fossil fuel consumption effected air pollution. Vehicle smoke pollution is a major source of air pollution [13]. With various attempts made to improve output power and efficiency, particularly in the new designs of induction motors. Small changes in the optimal design of induction motors can increase their efficiency and output power [14]. If the ambiance air entering the combustion chamber through the AC, then the ambiance air entering the combustion chamber is not pure as usual [15]. The study is to refer to the limit issued by the Ministry of Environment No. 05 of 2006 [16].

Figure 1. Traditional solid char production

Figure. 2 shows an activity of producing liquid smoke and charcoal on commercial scale. The process also regardless of the feed sizes. The wood log was jut feed into the big stove of brick made coated with clay to reduce the heat loss. Three or more stoves can be utilized in series as shown in Figure.2 (a) where the smoke is condensed by utilizing a simple condensing appliance such as oil drum. The sample product of liquid smoke at Figure. 2(b) has dark color shows that the quality of the liquid smoke is still low. A proper designed of a condenser is required to process the smoke further in order to get high grade of liquid smoke. The way of heating and start-up burning are very crucial step during process.

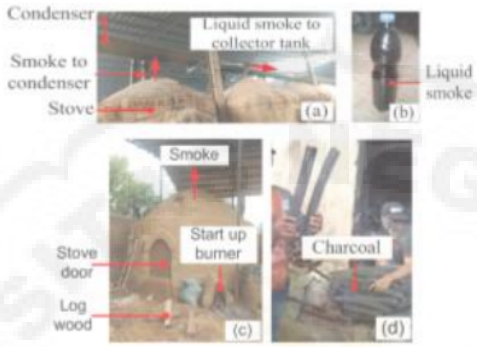

Figure 2. Traditional production of liquid smoke and charcoal

On traditional process, the start-up is conducted via direct burning. Several piece of wood log is burnt outside of the stove and the heat is injected into the stove through a small hole as shown in Figure. 2(c). Slowly, the log feed inside the stove undergo heating, remove all the volatiles. This process requires long time (in days) and the temperature inside the stove to be uncontrollable and can reach about 1000 ^{o}C. Despite, the product of charcoal can be obtained as shown in Figure. 2(d), however, the quality of the product needs to be improved to meet the consumer required.

2. Method

Coconut shell was used as raw material for pyrolysis. This material is widely available around the research area. This material is still considered to be kind of low value, but when the pyrolysis process is carried out, a highly valuable materials such as liquid smoke and charcoal are obtained. Coconut shells are collected, cleaned, and dried utilized the sunlight, then chopped to the sizes that are in accordance with the test required. There are four sizes required where the length and the width are considered the same in the ranges of 1 to 7 cm. A total of 2 kg of coconut shell was put into the pyrolysis reactor and the cover is locked tightly using nuts and bolts. LPG is used as a source of thermal energy to increase the pyrolysis operating temperature up to 250 ^{o}C for 180 minute operation. The operating temperature is maintained by adjusting the flow rate of the LPG. The temperature of pyrolysis reactor is monitored by using a thermometer. Water can which is filled with solid ice is used as the cooling medium during condensation. The temperature of the cooling water is detected using a thermocouple. During experiment, once the smoke produced is loomed through the tar separator for cleaning, the products are collected until the process is assumed complete if there are no more product is observed. The research apparatus as shown in the Figure. 3.

Figure 3. Experimental set-up

The collected data will be used to analyze the characteristic of the final product, namely the product and the quality of the liquid smoke obtained and will be used to improve performance both geometrical and operational and to improve the quality of the liquid smoke product. The product yield is calculated using the following expression.

$$\text{Liquid yield} = \frac{\text{Total liquid product weight}}{\text{Feed wight}} \times 100\% \quad (1)$$

$$\text{Charcoal yield} = \frac{\text{Char weight}}{\text{Feed wight}} \times 100\% \quad (2)$$

3. Result and Discussion

From the experimental results, the effect of coconut shell sizes on the liquid smoke and char products as shown in Figure. 4 below. From the picture, it can be seen that both products increase with increasing coconut shell size. However, both products have decreased when the coconut shell size is increased to 7 cm. The best product found at coconut shell sizes average of 5 cm where the char is found in the black color and the smoke liquid shows the transparent colour as shown in Figure 5.

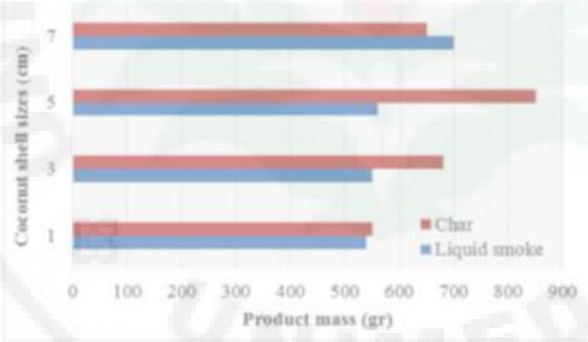

Figure 4. Effect of coconut shell sizes on the liquid and char at constant temperature of 250 °C

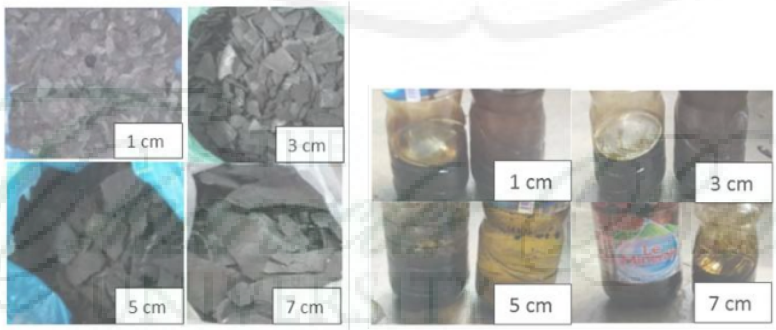

Figure 5. Charcoal and liquid smoke product

4. Conclusion

Based on the process that has been carried out, starting with the manufacture to testing on the pyrolysis reactor for liquid smoke producing equipment that the best product found at coconut shell sizes average of 5 cm where the char is found in the black color and the smoke liquid shows the transparent color.

References

[1] Rout, T., et al., Exhaustive study of products obtained from coconut shell pyrolysis. Journal of Environmental Chemical Engineering, 2016. 4 (3): p. 3696-3705.
[2] Mazela, B., Fungicidal value of wood tar from pyrolysis of treated wood. Waste Management, 2007. 27 (4): p. 461-465.
[3] Kahrl, F., et al., Greenhouse gas emissions from nitrogen fertilizer use in China. Environmental science & policy, 2010. 13(8): p. 688-694.
[4] Snyder, C.S., et al., Review of greenhouse gas emissions from crop production systems and fertilizer management effects. Agriculture, Ecosystems & Environment, 2009. 133(3-4): p. 247-266.
[5] Basu, P., Biomass gasification, pyrolysis and torrefaction: practical design and theory. 2018: Academic press.
[6] Rosendahl, L., Biomass combustion science, technology and engineering. 2013: Elsevier.
[7] Hasan H, Maksum H, Gunawan S, Eswanto E, Januariyansah S. Analysis of Using Gasoline-Corncob Waste Bioethanol Blends in Four-Stroke Motorcycle Engine onto Exhaust Emission and Compression Ratio. 2020;(January).
[8] Reed, T., J. Diebold, and R. Desrosiers. Perspectives in heat transfer requirements and mechanisms for fast pyrolysis. in Specialists Workshop on Fast Pyrolysis of Biomass, Proceedings: October 19-22, 1980, Copper Mountain, CO. 1980.
[9] Yorgun, S. and D. Yıldız, Slow pyrolysis of paulownia wood: Effects of pyrolysis parameters on product yields and bio-oil characterization. Journal of Analytical and Applied Pyrolysis, 2015. 114: p. 68-77.
[10] Gupta, G.K., P.K. Gupta, and M.K. Mondal, Experimental process parameters optimization and in-depth product characterizations for teak sawdust pyrolysis. Waste Management, 2019. 87: p. 499-511.
[11] Aguiar, L., et al., Influence of temperature and particle size on the fixed bed pyrolysis of orange peel residues. Journal of Analytical and Applied Pyrolysis, 2008. 83(1): p. 124-130
[12] Sundaram, E.G. and E. Natarajan, Pyrolysis of coconut shell: An experimental investigation. The Journal of Engineering Research [TJER], 2009. 6(2): p. 33-39..
[13] Hasan H, Gunawan S, Pakpahan BMT, Eswanto. Pada Karbon Aktif Tongkol Jagung Untuk Mengurangi Emisi Gas. 2020;6(2):93–9.
[14] Purwanto W, Maksum H, Sugiarto T, Risfendra R, Baharudin A. Optimal design of stator slot geometry for high-speed spindle induction motor applications. 2019.
[15] Gunawan S, Hasan H, Lubis RDW. Pemanfaatan Adsorben dari Tongkol Jagung sebagai Karbon Aktif untuk Mengurangi Emisi Gas Buang Kendaraan Bermotor. J Rekayasa Mater Manufaktur dan Energi. 2020;3(1):38–47.
[16] Maksum H, Purwanto W. Pressure analysis of the ideal intake manifold with the vibration parameters at the diesel engine. Journal of Physics: Conf. Series 1317, 2019.

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