Potential co-processing of coconut shell and sugarcane residue as a solid biofuel

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ABSTRACT – This research reported co-processing of coconut shell and sugarcane residue as a solid biofuel by briquetting process. The aim of the current research is to determine the optimum ratio between coconut shell and sugarcane residue for briquetting. Various ratios of coconut shell to sugarcane are 1:1, 1:3, 1:5 by weight. The briquettes were formed into cylindrical shapes. The carbonization process took place at 370℃. Proximate analysis, compressive test and theoretical heating value are observed on the produced briquette. The results indicated that C 1:5 briquette has the lowest moisture content and highest theoretical heating value.

1. INTRODUCTION

Biomass energy has received attention from entire world since the energy crisis in the mid-1970s. The research and development regarding this type of energy have been done widely. As a store sun energy, biomass gives economical and environmental benefits.

Fernández et al. [1] stated that biomass has several advantages compared to fossil fuel which is produce much lower NO_x and SO_2 emission to the atmosphere than fossil fuel. However, the carbon composition in biomass is lower than coal which is result in lower heating value. Furthermore, the volatile content of lignocellulosic fuels (80-90%) is twice than coal.

In coconut, about 15-20% part of coconut is coconut shell which is mainly consists of carbohydrates component such as cellulose, hemicelluloses and lignin. Coconut shell is classified as a hard lignocellulosic. The higher carbon content in coconut shell is making it suitable to be used in charcoal production [2].

Sugarcane is a potential source of ethanol and sugar. The by-product of sugarcane such as bagasse consists of 54.3 % of cellulose, 29.7 % of hemicelluloses and 24.4 % of lignin [3].

As agricultural waste, coconut shell and sugarcane have significant amount of hemicelluloses, cellulose and lignin which are potential to convert it as biofuel. The utilization of these types of biomass is seen as solution to reduce the waste disposal. Therefore, the main focus of this research is to modify these agricultural residues in order to obtain appropriate ratio for producing high quality of briquette. It is expected that this results will be useful in treatment of coconut shell and sugarcane residue as an energy source.

2. METHODOLOGY

2.1 Preparation of coconut shell and sugarcane bagasse samples

The raw materials of coconut shell (CS) and sugarcane residue (S) waste were obtained from Malacca area. The samples are first cleaned before crushing into smaller pieces.

The crushed coconut shell is dried at 104^{o}C for 24 hours while crushed sugarcane undergone drying process at 70^{o}C for 8 hours in a conventional oven. The dried samples were milled by a centrifugal milling machine (Retsch ZM 200) with 0.75 mm of mesh size. Furthermore, the milled samples were carbonized in the electrical furnace at 370^{o}C for 60 min.

In briquetting process, the carbonized samples are separated into three ratios as shown in Table 1. The CS and S were mixed physically until homogeneous mixture formed. 10.0 g of carbonized samples with decided ratio were densified into briquette with cylindrical mould by hydraulic press (Hsin-Chi Machinery HL 200). The mould has inner diameter of 35 mm and 10 mm of thickness.

Table 1 Ratio of coconut shell (CS) and sugarcane residue (S).

Ratio	CS (g)	S (g)	Sample codes	
			Non-carbonization	Carbonization
1:1	5.0	5.0	NC 1:1	C 1:1
1:3	2.5	7.5	NC 1:3	C 1:3
1:5	1.7	8.3	NC 1:5	C 1:5

2.2 Characterization of the coconut shell-sugarcane (CSS) briquette

A proximate analysis of CSS was conducted to determine the moisture content, volatile matter, ash content and fixed carbon. These analyses were carried out according to the American Society for Testing Materials (ASTM) D 3173-03, ASTM D 3174-02 and ASTM D 3175-02 standards [4]. Total organic matter is obtained by deduction the ash content from dry basis. The heating value of CSS briquette was estimated theoretically based on established Equation (1) founded by Erol et. al. [5]. To determine the compressive strength of briquette, compressive test is performed with Universal Testing Machine Instron 5583.

$$NHV = -116 - 1.33[Ash] - 0.005[VM] + 1.92[VM+Ash] - 0.0227\,[VM \times Ash] - 0.0122[VM]^2 + 0.0299[Ash]^2 + 6133[OM]^{-1} - 0.82[Ash]^{-1} \quad (1)$$

3. RESULTS AND DISCUSSION

Figure 1 provides the proximate analysis of CSS briquette. Proximate analysis covers the volatile matter, fixed carbon, moisture and ash content.

Volatile matter is gaseous products which is releasing during combustion. Both carbonized and non carbonized briquettes have almost constant value of volatile matter. The higher volatile matter content in briquette will produce more smoke during burning

The value of fixed carbon from NC and C briquettes is increasing with increasing the ratio as well. The C briquettes have fixed carbon values vary from 13.12, 13.90 and 14.25 % for C 1:1, C 1:3 and C 1:5 respectively.

It is crucial to determine the moisture content of the briquette sample because the moisture content affect quality of the produced briquette. The value of moisture content is decreasing when the ratio of coconut shell and sugarcane is increasing. It was found that the carbonization and non carbonization process affects the moisture content in briquette. The moisture content of carbonized samples is lower than non-carbonized samples. The highest moisture content was founded in NC 1:1 briquette (8.4 %).

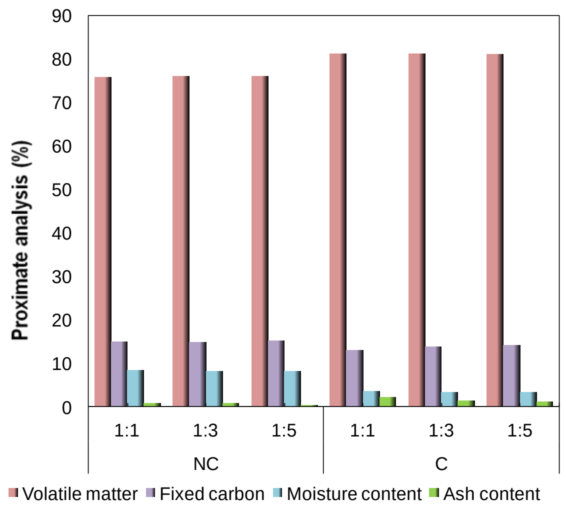

Figure 1 Proximate analysis of non-carbonized (NC) and carbonized (C) of CSS briquettes.

Table 2 Compressive test and theoretical value results of CSS briquettes.

Samples	Theoretical heating value (MJ/kg)	Compressive strength (kN)
NC 1:1	18.98	NA
NC 1:3	18.94	NA
NC 1:5	18.39	NA
C 1:1	18.80	18.20
C 1:3	18.97	10.60
C 1:5	19.00	10.30

Ash play important role in determining the quality of produced briquette. Ash content is the remaining residue that left after combustion and does not have any carbon content. Ash content for both carbonized and non-carbonized shows decreasing value as the ratio coconut shell is increasing in the briquette About 2.12 % of ash content in C 1:1 and the value is decreasing to 1.18 % for C 1:5. Moreover, the NC 1:5 has the lowest ash content.

In order to obtain the higher heating value, the briquette must have lower moisture content and higher ash content and fixed carbon.

Based on Equation (1), the highest heating value is 19.00 MJ/kg from C 1:5 briquette as shown in Table 2. The heating value increases as the ratio of coconut shell and sugarcane in briquette increased. However, the C 1:5 briquette has the lowest compressive strength.

4. CONCLUSION

The co-processing of coconut shell and sugarcane produced C 1:5 with theoretically highest heating value than non-carbonized briquettes. Presence of sugarcane residue also plays a role in heating value. However, due to the lowest compressive strength, the produced briquette required the further modification in future.

REFERENCES

[1] R.G. Ferńandez, C.P. García. A.G. Lavin, J.L. Bueno de lasHeras, Study of main combustion characteristics for biomass fuels used in boilers,” *Fuel Processing Technology*, vol. 103, pp. 16-26, 2012.

[2] J. Sarki, S.B. Hassan, V.S. Aigbodion, J.E. Oghenevweta, “Potential of using coconut shell particle fillers in eco-composite materials,” *Journal of Alloys and Compounds*, vol. 509, no. 5, pp. 2381–2385, 2011.

[3] K. Hofsetz and M.A. Silva, “Brazilian sugarcane bagasse: Energy and non-energy consumption,” *Biomass and Bioenergy*, vol. 46, pp. 564-573, 2012.

[4] American Society for Testing and Materials, Annual Book of ASTM Standards, Designation D 3173-03, D 3174-02 and D 3175-02, 2002.

[5] M. Erol, H. Haykiri-Acma and S. Kűçűkbayrak, “Calorific value estimation of biomass from their proximate analysis data,” *Renewable Energy*, vol. 35, pp. 170-173, 2010.