Design Of Coconut Fruit-Coat Charcoal Briquette-Presser And Its Product Characterization

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Abstract: The process of forming briquettes requires a tool that was able to compress the material, which consists of particles of charcoal powder and the adhesive used. This research was the initial stage of designing a briquette compression device with a material compression mechanism with manual hydraulic pressure. This research has succeeded in designing a briquette molding device that could mold a mixture of young coconut coat waste charcoal powder with starch adhesive by 10%. The resulting briquettes have an average height of 1.54 cm and a diameter of 3.21 cm. After drying the charcoal briquettes for two days, the moisture content was 7.79%. The results of the characteristic test of young coconut coat charcoal briquettes had the following properties: vapor content 26.74%, ash content 2.76%, bound carbon content 68.66 %, density 0.62 g/cm^3, firmness 32.44 kg/cm^3, and calorific value 6.21 cal/g. Charcoal briquettes from young coconut coat waste meet quality standards as community fuel based on Indonesian and Japanese Standards.

Index Terms: Briquett, charcoal, coconut coat, design, presser

1 INTRODUCTION

THE Real examples of the use of biomass energy derived from waste products of forestry and plantation activities and have been widely implemented are firewood and charcoal [1]. However, improvements are still needed for a more efficient use of charcoal. Charcoal briquettes can be made from a variety of materials, such as rice husks, wood, sawdust, corn cobs, fruit shells, and coconut shells. Likewise, the adhesive used can be in the form of starch, tapioca, molasses, tar, latex, young plant leaves and so on [2]. One of the fruit shells produced by young coconut ice traders in the City of Tasikmalaya was not utilized properly, so the waste accumulated to the landfill site. The waste takes a long time to decompose by microbiological and weather decomposition. Thus, the pyrolysis process of this waste will reduce its flow to the landfill. Proses pirolisis biomassa akan dihasilkan arang, asap cair, ter, dan biooil [3]. Carbonization by pyrolysis of 1,000 g of wood shavings waste produced charcoal, tar, biooil, and liquid smoke respectively 222 g, 41.76 g, 2.93 mL, and 482.67 mL [4]. The composition of sawdust charcoal from Ulin wood (Eusideroxylon zwageri) and albazia wood (Paraserianthes falcataria) as raw materials for making charcoal briquettes affects the quality of charcoal briquettes which include density, moisture content, compressive strength, volatile matter content, ash content, bonded carbon, and calorific value [5]. The process of forming briquettes requires a tool that can compress the material, which consists of a mixture of charcoal powder particles and the adhesive used. This research was the initial stage of designing a briquette forming tool with a material compression mechanism with manual hydraulic pressure.

The aims of this research were: (i) design a charcoal briquette printer from woody agricultural waste, especially young coconut fruit-coat charcoal; and (ii) determine the characteristics of young coconut fruit-coat waste charcoal briquettes.

2 EXPERIMNETAL SECTION

2.1 Design of Briquette Presser

Coconut coat waste (CCW) was taken from four young coconut ice sellers around the Field and Sports Stadium of Tasikmalaya City. Other materials needed: starch as briquette adhesive, distilled water as solvent, LPG as fuel, etc. The CCW chorcoal was generate by carbonized or pyrolized proses following the procedure of Rahmat et al. [6]. The tools used include: (i) a set of pyrolysis tools to produce charcoal, liquid smoke, and tar from CCW; (ii) Design made charcoal briquette printing equipment; and (iii) general experimental support equipment, such as: analytical balance, measuring cup, beaker, chemical bottle, pH meter, 40 mesh sieve filter, mortar, electric oven, etc. Supporting equipment includes: buckets, gloves, tape measure, etc.

2.2 Experimental Procedures

The production process of CCW charcoal briquettes is described as follows:

1) CCW raw materials were dried for seven days until the moisture content was estimated to be 20%.
2) The process of making CCW charcoal. The raw materials were charcoal (carbonized) by pyrolysis, so that they produce: charcoal, liquid smoke, tar, and biooil. The charcoal is removed after the pyrolysis kiln was cooled for 1 day.

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3) Charcoal produced in mortar and mortar to obtain charcoal powder, then sieved to obtain a uniform size of charcoal powder, which is 40 mesh.
4) The adhesive was made from a mixture of tapioca flour and water in a ratio of 1: 15. The mixing process is carried out at a temperature of 70°C while stirring slowly to form an adhesive gel.
5) The ratio of the mixture of charcoal powder and adhesive was 10:1. Then the two ingredients were stirred until smooth.
6) The dough was put into a briquette mold cylinder which had a diameter of 2.5 cm and a height of 4 cm.
7) The rod was compressed into the mold hole as a pressure with a height of about 6.4 cm. Compression was carried out with a hydraulic pressure of 20 bar for 10 minutes.
8) Drying of charcoal briquettes The resulting charcoal briquettes were dried using an oven at 60°C for 24 hours.
9) The dried charcoal briquettes were then put into a desiccator for 2 hours. Furthermore, the briquettes were stored in a room with a temperature of 20°C and a relative humidity of 65% for 7 days.

2.3 Briquetts Quality Test

According to [7], [8] and [9] calorific value of charcoal briquettes was measured on the following parameters:

(1) Water content

The test sample was weighed as much as 1 g, then put in an oven at a temperature of 104 to 110ºC for 1 hour until the weight was constant and weighed. The water content was calculated using the equation:

$$M = \frac{x_1 - x_2}{x_1} \text{ x } 100\%$$

Note :
M = water content (%)
x_1 = initial sample weight (g)
x_2 = Sample weight after drying (g)

(2) Volatile content

Weigh the crucible with the lid, filled with the specimen from the moisture content and placed in the furnace. Heat in a furnace with a temperature of 950 ± 20 ^{0}C for 7 minutes, then cooled in a desiccator and then weighed. The content of volatile substances is calculated based on the equation:

$$V = \frac{B-C}{W} \text{ x } 100\ \%$$

Note :
V = content of volatile matter (%)
B = sample weight after drying of 104 – 110 ^{0} C (g)
C = specimen weight after being heated in the vapor test (g)
W = weight of the initial sample (g)

(3) Ash content

A crucible cup without a lid and 1 g of specimen taken from the sample, placed in a furnace and heated at a temperature of 450 - 500 ^{0}C for 1 hour, then a temperature of 700 - 750 ^{0}C for 2 hours, then continued with ashing at a temperature of 900 - 950 ^{0}C for 2 hours. Remove the crucible from the furnace, and cool it in a desiccator and weigh immediately. Ash content was calculated based on the equation:

$$A = \frac{F-G}{W} \text{ x } 100\%$$

Note :
A = ash conten (%)
F = Weight of crucible and specimen (g)
G = Crucible empty weight (g)
W = Initial weight of specimen (g)

(4) Fixed-carbon content

Fixed carbon is the fraction of carbon (C) in briquettes, in addition to the fraction of water, volatile matter and ash. The fixed carbon content is calculated using the equation:

$$F = 100 – (M + V + A)\ \%$$

Note :
F = Fixed carbon (%)
M = water content (%)
V = colatile content (%)
A = ash content (%)

(5) Briquett density

Density was generally expressed in the ratio of weight and volume, namely by weighing and measuring the volume in dry air. The density of briquettes could be calculated using the equation:

$$K = \frac{G}{V}$$

Note :
K = density (g/cm^3)
G = briquett weight(g)
V = briquett volume (cm^3)

(6) Compressive strength

Compressive strength test was to measure the compressive strength of the briquettes by applying pressure until the briquettes break. Determination of compressive strength could be calculated using the equation:

$$S = \frac{P}{L}$$

Note :
S = compressive strength (kg/cm^2)
P = compressive load (kg)
L = surface area (cm^2)

(7) Calorific value

One gram of the sample in a silica cup was put into the bomb calorimeter tube. The tool used to determine this calorific value was a manual perioxide bomb calorimeter. Determination of calorific value could be calculated using the equation:

$$Cv = T_2 – T_1 – 0.05 \times m \times 0.24$$

Note :
Cv = calorific value of charcoal briquettes
T_1 = initial water temperature (^{0}C)
$T_{2.}$ = water temperature after burning (^{0}C)
0.05 = cemperature due to heat increase in wire
m = calorimeter specific gravity = 73529.6 (kJ/kg)
0.24 = constant 1 J = 0.24 kal

3 Results and Discussion

3.1. Briquett-presser Design

(1) Technical design

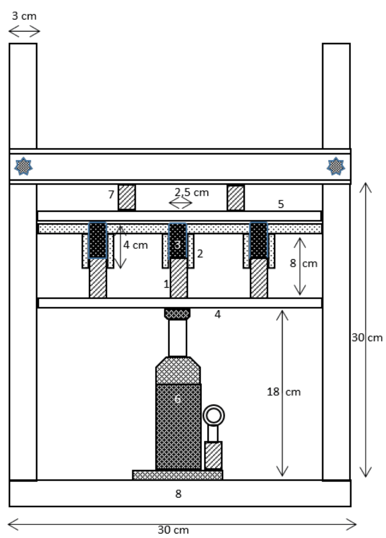

Figure 1. Technical specifications for charcoal briquette-presser (Scale 1:9). Description: (1) compression rod; (2) charcoal storage cylinder; (3) charcoal mix; (4) pressure plate; (5) top retaining

When the compression rod pressed the mixture of charcoal powder and adhesive in a holding cylinder, then by applying a pressure of 20 bar it compressed the mixture into a solid, namely charcoal briquettes, which were still wet.

(2) Work steps

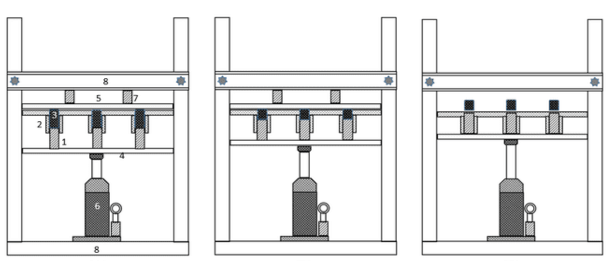

Figure 2. Sequence of the charcoal briquette molding process (Scale 1: 15), included three stages as follows: (A) Filling the charcoal mixture; (B) Compression of the charcoal mixture; and (C) Release of charcoal briquettes.

The mechanism compressed the mixture into a compact mass. Furthermore, when the top retaining plate was removed, the nine briquettes formed will rise and fall out of the mold cylinder.

(3) The tool and product of briquett presser

Figure 3. Photograph of briquett-preser and its product.

Briquettes with a diameter of 3.2 cm and a height of 1.8 cm, turned out to have a weight of 8,97 g at a moisture content of 7.79 %.Charcoal briquettes are charcoal particles which are further processed into a form of briquettes that can be used for daily energy purposes. The raw materials were charcoaled first and then grinded, mixed with adhesive, molded (cold pressing) with a manual hydraulic system and then dried [2]. It has been investigated making corncob charcoal briquettes by adding adhesive to corncob charcoal that has been mashed, then molded in a cylindrical shape with the help of a press [10].

3.2. Product of Pyrolisis Process

The results of the pyrolysis of 1,000 g of coconut fruit-coat with a moisture content of 20% in this experiment produced charcoal, liquid smoke, tar, and biooil were 300, 400 mL, 23 g, and 5 mL, respectively. This was not much different from the previous study, sawdust waste (1,000 g) with a water content of 20% was used as feedstock per unit of liquid smoke produced. The sawdust was heated to 450°C for 45 min, in the absence of air or oxygen, in the airtight kiln. The crude distillate contained liquid smoke, chorcoal and tar, all collected in the condenser outlet [6,11]. Likewise, the pyrolysis process of 1,000 g of teak-wood shavings produced 367 g, 312 mL, 31 g, and 5 mL of charcoal, liquid smoke, and tar respectively [12].

3.3. Charaterristics of CCW Choarcoal Briquetts

Based on the tests carried out, the characteristics of young coconut coat waste (CCW) charcoal briquettes are as shown in Table 1.

TABLE 1
Characteristics of CCW charcoal briquettes

Test Parameter	CCW Briquett	Standard	
		Indonesian	Japanese
Water content (%)		8	6 - 8
Volatile content (%)	7.79	15	15-30
Ash content (%)	26.7	8	3 - 6
Fixed carbon content (%)	4	77	60 - 80
Density (g/cm^3)	2.76	-	1.0 – 1.2
Compression str. (kg/cm^3)	68.6	-	60 - 65
Calirific val. (kal/g)	6	5,000	6,000 –
	0.62		7,000
	32.4		
	4		
	6,211		

The water content of charcoal briquettes affects the calorific value, namely when the water content is higher, the calorific value is lower. Charcoal briquettes have high hygroscopic properties, so the value of water content can be used as a basis for quality. The water content of the briquettes from the samples from this study, was below the Indonesian Standard (SNI) value, which was 8% [13]. This proves that the value of the water content meets the requirements. The high and low moisture content of charcoal briquettes is determined by the type of biomass origin, for example albazia wood which has a lower density than ulin wood and its hygroscopic properties are stronger, so it has a higher moisture content of charcoal briquettes [5]. The volatile content in the test sample briquettes had a higher value than the Indonesian and Japanese Standards. This fact showed that young coconut coat charcoal briquettes not met quality standards. The higher volatile content will produce more smoke when the briquettes were burned. The smoke arised due to the reaction of carbon monoxide (CO) with alcohol derivatives [9]. The ash content of the test sample briquettes of 2.76% was still below the Indonesia Standard, but it was within the range of the Japanese Standard. So the charcoal briquettes qualify as a potential alternative fuel. High ash content can reduce the calorific value of charcoal briquettes so that the quality of the charcoal briquettes decreases [14]. The results of the fixed carbon content test of the coconut shell charcoal briquette sample obtained a value of 68.66%, which is lower than Indonesian Standard and is in the range that meets Japanese Standards, thus meeting the quality of the fuel. Fixed carbon is affected by the specific gravity of the raw material, the carbonization process and volatile substances. High density of raw materials will produce high bound carbon. On the other hand, having a low volatile substance will increase the bound carbon [5]. Young coconut coat charcoal briquettes had a density of 0.62 g/cm^3, which was still below the Japanese Standard range. It was presumed that in the charcoal briquettes there were still alot empty inter-particle space, as a result of the non-uniform particle size and insufficient compression. Previous research showed that charcoal briquettes from coconut shells had the highest bulk density value of 0.86 g/cm^3, while charcoal briquettes from Madan wood were 0.68 g/cm^3, which was the lowest. Based on this work, it could be concluded that what affected the bulk density was the specific gravity of the material itself [15]. The compressive strength of briquettes is the ability of briquettes to provide resistance or briquette cohesiveness against breaking or crushing when a load was applied to the object. The higher the value of the compressive strength of the charcoal briquettes, the better the resistance of the briquettes to breaking [16]. The compressive strength of coconut coat charcoal briquettes was 32.44, which was still below the Japanese Standard. This showed that the composition and compression process had not met the requirements. This improvement in the quality of compressive strength is very important for the durability of briquettes in packaging and ease of transportation. The calorific value of charcoal briquettes from the test was 6,211 cal/g which was in the range of Japanese quality standards (6,000-8,000 cal/g) and higher than Indonesian Standard Number SNI-01-6235-2000 (5,000 cal/g) [13]. The calorific value of the charcoal briquettes was higher than that of the nipah fruit coat charcoal briquettes, which was 5438.80 cal/g. Thus, based on its calorific value, this charcoal briquette met quality standards [9].

4 Conclusion

Based on the results of the experiments carried out, the following conclusions were drawn:

1) The designed briquette press can mold materials consisting of a mixture of young coconut coat charcoal powder with starch adhesive of 10%, it turned out that briquettes were obtained with an average height of 1.8 cm and a diameter of 3.2 cm. After drying the charcoal briquettes for two days, the moisture content was 7.79%.
2) After characterization of young coconut coat charcoal briquettes, data obtained : volatile content 26.74%, ash content 2.76%, fixed carbon content 68.66 %, density 0.62 g/cm^3, compression strength 32.44 kg/cm^3, and the calorific value 6.21 cal/g.
3) Young coconut fruit-coat waste charcoal briquettes met quality standards as an alternative fuel for the community based on Indonesian and Japanese Standards.

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