Production of biomass briquettes from septic tank at pilot scale

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Abstract. Production of biomass briquettes has been conducted at pilot plant scale. Briquettes are a material in the form of powder which are pressed using a machine mixed with adhesive so that they become a solid shape. The process for making briquettes is by adding polyacrylamide as adhesives. The process stages in making fecal briquettes are based on a predetermined procedure, there are several steps, starting from weighing the feces sludge, adhesive (polyacrylamide), water then stirring until printing or pressing, and heating the briquettes in the oven. The best briquettes are produced from sixteen (16) types of briquettes with the longest burning time of 613 seconds and a heating value of 7436.55 cal/g which is obtained from the ratio of raw material: adhesive, pressure scale, and drying time respectively 5 : 2; 105 kg/cm²; and 120 minutes, with moisture content and density values respectively 7.27% and 1.06 gr/cm³. Where the moisture content and briquette value obtained have met SNI, namely ≥ 5000 Cal/g and 7.75%, respectively, in addition, the briquette density obtained has met the American standard, namely 1.0 gr/cm³.

Table 1. Summary of research results of briquette making

| No | Researcher/Year | Research Title | Raw Materials/Process Variables | Result |
|----|-----------------|----------------|---------------------------------|--------|
| 1  | Anisah Salji/2017 | Variation of Material Concentration, Molasses, and Pressure on Briquetting Coconut and Rice Husk | Coconut shell and rice husk/ratio 75 : 25 and 50 : 50 with molasses adhesive 80, 60, and 30% of the amount of raw material and the pressing pressure of 20 kg/m² and 25 kg/m² | Water content: 2.96% Ash content: 32% Combustion rate: 32% Calorific Value: 11,768 cal/g |
2 Heruwati/2009 Effect of Variation Pressure on Briquette Making Shell Charcoal Coconut with Leaf Adhesive Young Cashew (Anacardium occidentale L.) to Generated Calorific Value.

The raw material used is shell charcoal coconut uses guava leaf adhesive young cashews. Comparison coconut shell charcoal with adhesive is 87.5% : 12.5% with variations in pressure 50 kg/cm², 100 kg/cm², 200 kg/cm², and 300 kg/cm². Calorific value the tallest obtained on pressure 300 kg/cm² that is 4,334 kcal/kg or 4,334 cal/g and deficient stickiness to briquettes.

3 Monika Cahyani Ratri and Sri Yamtinah/2012 Briquette Making Charcoal from Waste Organic by Using a Variation of Composition and Material Size

Coconut shell, bagasse and water hyacinth / adhesive : Tapioca flour with a composition ratio of 6 : 1 : 1 ; 4 : 2 : 2 and 2 : 3 : 3

Water content 1.90-4.30%, lowest volatile matter content 16.31-27%, ash content 2.65-12.80%, fixed carbon content 55.9-79.15%, heating value 4641.18 - 6156.25 cal.

4 Emerhi/2011 Physical and Combustion Properties of Briquettes Produced from Sawdust of Three Harwood Species and Different Organic Binders

Powder mixture saws of three types hardwood : dirt cow = 70 : 30, sawdust : ash wood = 70 : 30, sawdust : starch = 70 : 15 with sawdust mixture per combination = 50 : 50 (20 grams)

The calorific value the highest of powder mix Afzelia’s saw Africana and Terminalia superba with starch adhesive namely 3,316 kcal/kg or 3,316 cal/g

The composition of briquettes from feces (human feces) based on Indonesian National Standard (SNI) is shown in Table 2.

| Parameter                     | Value   |
|-------------------------------|---------|
| Water content (%)             | ≤ 8     |
| Ash content (%)               | ≤ 8     |
| Carbon content (%)            | ≥ 77    |
| Calorific value (cal/g)       | ≥ 5000  |

Based on the Table 2, it can be seen that when compared with some of the chemical properties of this briquette it is still included in the SNI. In the proper standard rules for briquettes, that is seen from the water content that is in accordance to SNI is ≤ 8%, then the ash content is ≤ 8%. After that the carbon content is ≥ 77% and the heating value according to SNI is ≥ 5000 cal/g. This parameter can be used as a reference standard for making fecal briquettes.

2. Materials and methods

Briquettes are lumps made of soft, hardened material. Briquettes are an alternative fuel that has good prospects to be developed. Because apart from the easy manufacturing process, the availability of raw materials is also easy to obtain [3]. Materials sourced from waste can be used in making charcoal.
briquettes. One of these materials is plantation waste, namely rubber seed shells. In addition to rubber seed shells, the manufacture of briquettes is varied with plantation waste, namely coconut shell charcoal.

To determine the good quality of the briquette charcoal produced, it can be seen from the results of chemical testing including moisture content, ash content and volatile substance content, while physical testing uses sensory testing of texture, color, and burning time. The purpose of varying coconut shell charcoal with rubber seed shells is to determine how much influence the different compositions have on the observed parameters.

The scientific properties of powdered charcoal tend to be mutually exclusive. The help of an adhesive or glue agent makes charcoal grains put together and shaped as needed. However, the problem lies in the type of adhesive to choose. The determination of the adhesive material used greatly affects the quality of the briquette when it is burned and ignited. The price factor and its availability in the market must be considered carefully because each adhesive material has different adhesion characteristics [4].

2.1. Fecal Sludge Treatment Plant
The sludge treatment plant has several machine tools, namely inlet tub, pH motor valve, receiving tank, coarse screen, fine screen, equalization tank, thickener, centrifugal pump, polymer mixer, belt press, aeration tub, cake drying bed and other equipment. Table 3 shows the equipment used in the plant.

| Equipment                      | Function                                      | Figure |
|--------------------------------|-----------------------------------------------|--------|
| 1. Inlet Tub                   | as an initial container for fecal sludge      |        |
| 2. pH Motor Valve and Flow Meter| to control sludge in the tub                  |        |
| 3. Receiving Tank              | to dispose of sludge into the coarse screen   |        |
4. Coarse screen to filter out large trash

5. Fine screen to filter out smaller garbage that is not filtered out by the coarse screen

6. Equalization basin as a water collector to level or uniform the quality of treated wastewater

7. Thickener as a disposal area for biological and chemical process sludge

8. Centrifugal pump to suck the sludge from the thickener to the belt press machine
9. Polymer mixer bath as a place for mixing chemicals as a sludge binder

10. Belt Press as a means of separating mud from water, so that the mud has a lower water content (cake-shaped mud)

11. Aeration tub as a place to reduce levels of organic substances in wastewater by utilizing the ability of aerobic bacteria

12. Cake drying bed for drying sludge and reducing pathogenic bacteria

2.2. Briquette Making Process

The process of making fecal briquettes is quite complicated, but not too difficult to put into practice. The simple process that can be done is as follows:

1. Prepare materials
   At this stage, the material to be made into briquettes must be materials that contain strong cellulose and sufficient methane gas (CH₄) to start combustion. In this process, unnecessary constituent materials such as gravel are separated so that a good main ingredient is obtained.

2. Separating fine and coarse materials with the Fine Screen separator.

3. Prepare flour and dilute it with water so that it becomes a dough like mush as an adhesive (glue)

4. Mix starch glue with charcoal flour in a ratio (1 : 9) so that it becomes a sticky material. Furthermore, the ingredients are stirred so that all they are evenly mixed and sticky enough.

5. The material that is already sticky is then printed on the printer.

6. The briquettes are dried in the sun for 2-3 days until they are completely dry.
7. The briquettes are ready to be used as fuel.

2.3. Briquette Printing and Pressing
In order to support the business of providing and developing energy use in rural areas, research is conducted in the field of rice husk briquettes and peanut shells as alternative fuels. One of the properties studied is the effect of pressing pressure and heating temperature on the thermophysical properties of the briquettes. This study specifically aims to determine the effect of variations in pressing pressure, the effect of heating temperature and the interaction between pressing pressure and heating temperature on the thermophysical properties of rice husk briquettes and peanut shells which include: moisture content, calorific value, density and ash content [5].

2.4. Briquette Drying
Based on the method, there are 2 methods used to dry briquettes, namely natural drying and artificial drying.

1. Natural drying
The briquettes can be dried by using sunlight or drying the prints arranged in a basket or perforated wire basket, then spread out in the open so that sunlight is free to enter. During drying, the briquettes are turned back and forth so that they heat evenly.

2. Artificial drying
One of the means of artificial drying is using an oven. Oven drying is applied to reduce the water carbon content quickly without being hindered by climatic and weather factors. The oven uses a heating element as its main component.

2.5. Briquette Quality Test
The study used a completely randomized design (CRD) with a combination of treatments of six experimental variations. Repetitions were carried out 3 times in order to obtain 18 experimental units. The treatment factors used in this study were the amount of adhesive (P1 = 4% adhesive, P2 = 6% adhesive, P3 = 8% adhesive) and the drying process (M1 = oven drying, M2 = sun drying). The variables observed in this study include moisture content, heating value, ash content and volatile matter content, as well as energy needs including human energy, solar energy, fuel energy, electrical energy and total energy requirements. The data used are primary and secondary data. The data obtained were analyzed using the f test, 5% level DMRT test and T test. The results showed the chemical properties of dregs briquettes without carbonization process by oven drying and sunlight, namely moisture content (3.31% - 8.24%), ash content (6.10% - 7.77%), volatile matter content (4.85% - 5.66%), and heating value (5260.82 cal/g - 5412.96 cal/g), compared to briquettes with carbonization process, namely water content (3.18% - 6.81%), ash content (7.79% - 9.69%), volatile substances (11.08% - 8.16%), and calorific value (6013.93 cal/g - 7081.72 cal/g) [6].

The combination of the amount of adhesive and the drying process has a significant effect on moisture content, ash content and calorific value. The carbonization process has a significant effect on volatile matter content, ash content, and heating value. Briquettes without carbonization process have quality in terms of ash content but not in calorific value. The ratio of energy use in making briquettes without carbonization process by oven drying is 5.98 : 3.78, with sun drying of 3.78. The ratio of energy use of briquettes with the carbonization process with oven drying is 7.25. The carbonization process of briquettes is still better because the input energy (E_{in}) is proportional to the output energy (E_{out}) produced.

3. Discussion
The production process in the briquette-making process uses biomass as raw material in the form of dried human feces. Meanwhile, the adhesive used as a matrix is polyacrylamide. The research was started by mixing raw materials and adhesives with variations in the ratio of raw materials and adhesives 2 : 1 and 5 : 2, then the briquette dough was formed into a cylinder and pressed with a printing machine with a press scale variation of 85 and 105 kg/cm². In the last stage, after the briquette dough is formed,
the briquettes are dried using an oven at a temperature of 150°C with a variation of the drying time of 90 and 120 minutes. During the briquette production process, there were difficulties when mixing the polymer with feces which resulted in the quality of the briquettes such as cracks on the surface of the briquettes [7].

Briquette Quality Testing Analysis.

a. Analysis of Calculation of Water Content

Testing the quality of briquettes that needs to be considered is how much% of the water content is in the briquettes and SNI for the water content in the briquettes. From the results of this study, it was found that the average% water content in briquettes was 11.38%. The higher the water content contained in the briquettes, the lower the quality of the briquettes, but if the less water content is contained in the briquettes, the better the quality of the briquettes. The largest percentage of water content from the results of this study was 17.80%, which was obtained from the 9 types of briquettes, namely briquettes with the ratio of raw material: adhesive, pressure scale, and drying time respectively 2:1; 85 kg/cm²; and 90 minutes. Meanwhile, the smallest percentage of water content from the results of this study was 7.06%, which was obtained from the type of briquettes 4, namely briquettes with the ratio of raw material: adhesive, pressure scale, and drying time respectively 5:2; 105 kg/cm²; and 120 minutes, where% SNI water content is 7.75%.

From the experimental results, it was found that during the briquette-making process, the parameters of the ratio of raw material: solvent, pressure scale and drying time greatly affected the moisture content of the briquettes produced. A larger pressure scale and a longer drying time will increase the density and will suppress the moisture content in the briquette so that it will produce high density with low moisture content [8].

Moreover, it was obtained that the type of briquette with the lowest water quality was 7.06% in the type 4 briquette with the characteristics of the briquette, namely the raw material: adhesive ratio of 5:2, a pressure scale of 105 kg/cm², and a drying time of 120 minutes. In Indonesia, the water content standard for wood charcoal briquettes with wood raw materials has been established through a standard, namely SNI, where the water content standard set is ≤ 8% [1], while the quality standard for briquettes in Austria, Germany, Sweden, France, Japan, England and America are <10 each; <12; <15; 6-8; 3.6; and 6.2%. From these results, the third best briquette moisture content obtained has met the standards set by SNI. However, the average moisture content and most types of briquettes produced still do not meet SNI.

b. Analysis of the Calculation of the Ignition Time of Briquettes

Testing the quality of briquettes needs to be considered how long it takes to ignite the briquette fuel and how long it takes to ignite the briquettes until they turn to ash. The compressive force of the briquettes will affect the speed at which the briquettes burn out. The rate of combustion is seen from the length of time the briquette burns out and the temperature that occurs in the briquette [9].

The initial length of time needed to ignite the briquettes to turn ash can be seen that briquettes with a press scale of 105 kg/cm² have a longer burning process than briquettes with a press scale of 85 kg/cm². This is because the higher the pressure the briquettes become tighter (higher density) so that the contact between the particles will be higher. High density briquettes will make it easier to burn the briquettes at a certain mass per briquette volume so that combustion lasts longer. Whereas briquettes with lower pressure will have gaps/spaces in the briquettes so that combustion takes place faster. The results of the research on biobriquette combustion rates are in accordance with the previous research in the research on municipal waste briquettes, different combustion times were produced at each pressure, for example the compressive force of 100, 150 and 200 kg with the combustion time being 195, 250, 185 minutes. The compressive force of 150 kg represents a longer burning time. The results showed that the briquette with the longest burning time was 613 seconds, obtained from the type of briquette 16, where the ratio of raw material: adhesive, pressure scale, and drying time were 5:2 respectively; 105 kg/cm²; and 120 minutes, with moisture content and density values respectively 7.27% and 0.106 gr/cm².
c. Briquette Density Calculation Analysis

The calculation of briquette density in testing the quality of briquettes that needs to be considered is how big the radius, height and mass produced from the briquette. There are sixteen types of the best briquettes obtained from the results of the burning time analysis, which is then measured for density. Where the density itself is the density level of a substance at a certain mass and volume. The highest briquette density was obtained in the 8th type with a density reaching 1.14 gr/cm$^3$. The average density of briquettes obtained was 0.97 gr/cm$^3$. From the experimental results, it can be seen that the higher the pressure scale will increase the density value of a briquette. Increasing density will increase the length of time and the rate of combustion. In addition, high densities tend to provide a higher calorific value than low density ones [10].

The results showed that the three best briquette density values obtained had met the briquette quality standards in America, namely 1.0 gr/cm$^3$, but still smaller than the briquette quality standards in Japan (1.0-1.2 gr/cm$^3$) and United Kingdom (1.48 gr/cm$^3$). For charcoal briquettes made from feces and wood raw materials in SNI, the density value is not required.

d. Calorific Value Calculation Analysis

The calorific value of the tenders increases with increasing pressure scale and drying time, and tends to decrease with increasing water content. The results showed that the highest calorific value was obtained from the sixteen type of briquettes, with a heating value of 7,436.55 cal/g, where the ratio of raw material: adhesive, pressure scale, and drying time were 5 : 2 respectively; 105 kg/cm$^2$; and 120 minutes. From the results of the research conducted, the calorific value of the briquettes obtained is in accordance to the standard heating value of wood briquettes according to SNI which is ≥ 5000 cal/g.

4. Conclusion

1. The best drying time for briquettes is 120 minutes at 150°C in the oven.
2. The higher the amount of water contained in the briquette, the lower the quality of the briquette.
3. From the research, it was obtained that the moisture content, density and average calorific value of the briquettes were 11.38%; 0.969 gr/cm$^3$; and 6194.21 cal/g.

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