The Effect of Pyrolysis Temperature on Charcoal Briquettes from Biomass Waste

by Sri Wahyu Murni

Available online at: http://proceeding.rsfpress.com/index.php/ebs/index
LPPM UPN "Veteran" Yogyakarta Conference Series
Proceeding on Economic and Business Series (EBS)
Volume 1 Number 1 (2020): 453-460

The Effect of Pyrolysis Temperature on Charcoal Briquettes from Biomass Waste

Sri Wahyu Murni, Tutik Muji Setyoningrum
Universitas Pembangunan Nasional Veteran Yogyakarta
[1] E-mail address sriwahyumurni@upnyk.ac.id; [2] E-mail address tutikmuji@upnyk.ac.id

Abstract

Increasing people's energy needs requires alternatives, one of which is using agricultural waste materials. Charcoal briquette is a solid fuel made from charcoal with a pressing process so that it coagulates with a certain density, can be burned continuously, and has a high-calorie value. Conversion of various kinds of agricultural waste to charcoal briquettes needs to be done in order to meet the SNI requirements. In this research, briquettes will be made from raw materials of peanut shells, rubber seed shells, and snorkeling wood because they have high cellulose content. The aim of this research is to produce charcoal briquettes and test their characteristics. The study was designed with 2 variables, namely the type of raw material (peanut shells, rubber seed shells, and snorkeling wood) and pyrolysis temperature: 300, 400, 500, and 600°C. The size of the charcoal powder is -35 +50 mesh, 8% starch adhesive, and 100 kg / cm2 of pressing pressure. The parameters measured were moisture content (%), ash content (%), volatile matter content (%), and fixed carbon content dan calorific value (cal/g). The results showed that the best characteristic of charcoal briquettes was obtained from rubber seed shells, the temperature of pyrolysis of 600°C, with the moisture content of 7.4%, ash content of 3.55%, volatile matter content of 13.44%, fixed carbon content of 75.92% and calorific value of 7105 cal/g.

Keywords: adhesive, agriculture waste, briquette, charcoal, calorific value

I. INTRODUCTION

The increasing need for energy demands efforts to find alternative raw materials that can be converted into fuel. Agricultural waste is an abundant raw material, which can be used as solid fuel after being converted into briquettes. Charcoal briquettes are solid fuels made from organic waste, factory waste, and urban waste. This solid fuel is an alternative fuel or a substitute for the cheapest fuel oil and is possible to be mass developed in a relatively short time considering the relatively simple technology and equipment used. The utilization of agricultural waste containing organic elements can be made briquettes by using a pyrolysis process mixed with an adhesive. Research on the use of agricultural waste has been done a lot, but the results of the research have not met the standards set by the National Standard Agency for briquettes. Requirements for the quality of briquettes according to the Indonesian National Standardization Agency (SNI 01-63235 / 2000)

II. LITERATURE REVIEW

Pyrolysis is the thermal breakdown of large molecules into small molecules in the absence of oxygen. (Fessenden, 1994) Pyrolysis generally starts at 200°C and lasts at temperatures around 450-500 °C. Pyrolysis of biomass will produce three kinds of products, namely gas, liquid, and solid (char) products. The amount of product gas, liquid, and char depends on the type of process. (Sheth & Babu, 2006) The pyrolysis process is divided into several stages; on preheating, the water content evaporates, then the cellulose breaks down to a temperature of 200°C. The distillate that occurs mostly contains methanol, vinegar, and other acids, specially produced at a temperature treatment of 200-260°C. At a temperature of 260-300 C cellulose is intensively decomposed, at this stage a lot of smoke, gas, and less water is produced. At a temperature of 310-500°C lignin decomposes and generates a lot of tar, while smoke and gas decrease, most of the tar from the decomposition of the lignin. With increasing temperature and length of time, the resulting CO_2 gas decreases, while CO, CH_4, and H_2 increase. The optimal briquette obtained is influenced by the time and temperature of pyrolysis. Time affects the products produced because of the longer pyrolysis time, the product will increase. Pyrolysis temperature affects the product was obtained according to the Arrhenius equation, the higher the temperature of the thermal decomposition constant, the greater the effect of increasing pyrolysis rate and conversion increase.

The advantages of using biomass waste to produce briquettes are cheaper fuel costs, stoves can be used for various types of briquettes, more environmentally friendly. Renewable energy sources, help overcome waste problems, and reduce waste management costs. The simple criteria for a material to become a fuel are: 1) it has a high calorific value that is sufficient for the standard, 2) The amount of available material is sufficient, 3) flammable, and 4) comfortable in use. Good charcoal for fuel has characteristic as follows: 1) black color with a bluish flame, 2) shiny on the shards, 3) does not contaminate hands, 4) burns without smoking, does not splash and has no smell, and 5) can burn continuously without in the fan. The factors that affect the properties of charcoal briquettes are the specific gravity of the fuel or the density of charcoal powder, powder fineness, carbonization temperature, and pressure. Briquettes can be made from a variety of raw materials, such as bagasse, rice husks, sawdust, and agricultural waste materials. The main ingredient that contains the raw material is cellulose. The higher the cellulose content, the better the quality of the briquettes. The briquettes that contain too high volatile matter tend to give off smoke and have an unpleasant odor. To glue the raw material particles in the briquette-making process, an adhesive agent is needed so that a compact briquette is produced.

Not all agricultural waste can be converted into fuel. Charcoal briquette can be used as fuel if it has a calorific value was more than 5000 cal/gram. Calorific values are determined by the type of raw material. In this study, charcoal briquettes were made by the pyrolysis process of agricultural waste, then the charcoal was the reduced size, mixed with adhesive, pressed, dried, and tested its characteristics.

III. RESEARCH METHODOLOGY

III.1. Material

Agricultural waste in this research were peanut shells, snorkeling wood, and rubber seed shells. The material is cleaned, washed, and dried in the sun to a moisture content of 10%. The cassava starch was used as an additive.

III.2. Methods

III.2.1. Pyrolysis

Peanut shells, snorkeling wood, and rubber seed shells are put into the pyrolysis tube/ retort (Fig 1.). The pyrolysis tube is closed tightly by tightening the bolts and then connected to a heat source in the form of an electric current through a temperature regulator which has been set at a certain temperature. After the pyrolysis is complete, which is indicated by the absence of smoke coming out, the equipment is then turned off and left to stand for one day.

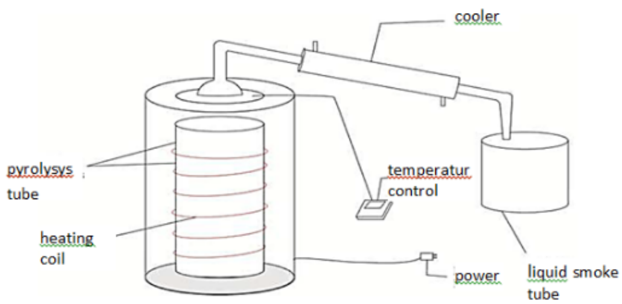

Fig 1. Pyrolysis Apparatus

III.2.2. Making briquette

III.2.2.1 Reducing size dan Sifting

The pyrolyzed charcoal is crushed with a disk mill to obtain the specified mesh size. The grain size used in making briquettes is -35 + 50 mesh.

III.2.2. Mixing and pressing

The powdered charcoal is mixed with an adhesive. The adhesive used is starch mixed with water (10%). The briquette molding process is carried out to give the briquettes shape, making it easier to use, handling, and storage. Pressing is done by a compaction process with a compressive strength of 100 kg/ cm^2. This process is intended to suppress as much moisture as possible in the mixture of raw materials for making briquettes. This is to accelerate the drying of the briquettes and increase the heat content generated in the briquette combustion process.

III.2.3. Drying charcoal briquettes

The drying process is carried out after the pressing to evaporate or remove the moisture content. The drying process was carried out in an oven at 80^0C for 2 hours

III.2.4. Charcoal Briquette Analysis

Charcoal briquettes were analyzed in accordant with ASTM standart, as follows: moisture content (ASTM D-3173), ash content (ASTM 3174), volatile matter content (ASTM D-3175), fixed carbon content (ASTM D 5142-02) and calorific value (ASTM 2105).

IV. FINDING AND DISCUSSION

Charcoal briquettes from rubber seed shells, snorkeling wood, and peanut shells were produced by pyrolysis at various temperatures then mixed with the same amount of adhesive. The characteristic of briquettes then was tested. The effect of temperature on the characteristics of briquettes is presented in the following discussion.

IV.1. Moisture Content

The moisture content in charcoal briquettes has an effect on the calorific value and the combustion. The material type and temperature influenced the moisture contents. The water content of charcoal briquettes based on SNI is a maximum of 8%. The highest water content (7.5%) in charcoal briquettes from snorkeling wood at pyrolysis temperature of 600°C while the lowest water content (6.03)% in charcoal briquettes from peanut shells. The effect of temperature on the moisture content of briquettes is presented in Fig 2.

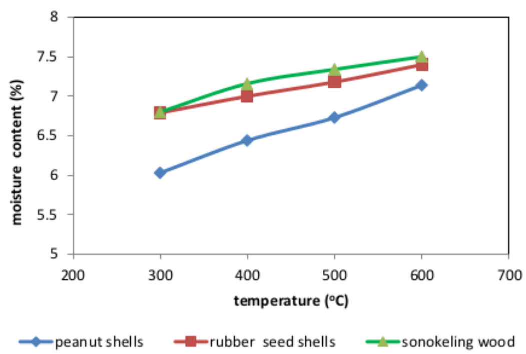

Fig 2. The effect of temperature on moisture content

At a higher pyrolysis temperature, the charcoal will have a higher ability to absorb water, so that at higher temperatures, the water content of the charcoal briquettes will be greater. Generally, high moisture content leads to briquette swelling and easy degradation of briquettes. (Zubairu, 2014)

IV.2. Ash Content

Ash is the remaining part of the combustion product, the main element of ash is silica which has less effect on the resulting calorific value, the higher the ash content, the lower the briquette quality. Ash contained in solid fuel is a mineral that does not burn during the combustion process. The ash content of briquettes based on SNI 01-6235-2000 is a maximum of 8%. The effect of temperature on pyrolysis on ash content is presented in Figure 3.

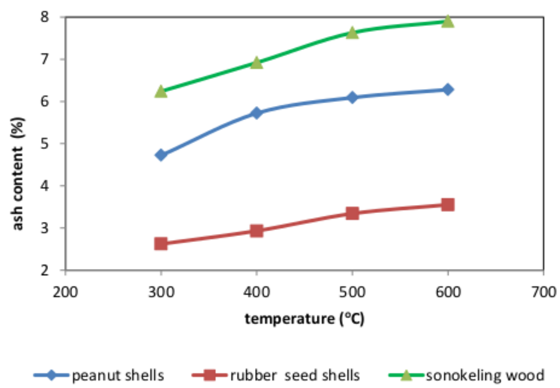

Fig 3. The effect of temperature on ash content

Ash content is influenced by the type of material, rubber shell has the lowest ash content while snorkeling wood has the highest ash content, so the pyrolysis results show the same thing. Charcoal briquettes from rubber seed shells showed the highest ash content, whereas charcoal briquettes made from snorkeling wood contained the greatest amount of ash. As high as pyrolysis temperature, the ash content increases, because the volatile matter content decreases. The results showed that the lowest ash content (2.62%) was found in charcoal briquettes from rubber seed shells, while the highest ash content (7.90%) was found in charcoal briquettes from snorkeling wood.

IV.3. Volatile Matter Content

Volatile matter content is volatile substances that can evaporate which is the result of the decomposition of substances that are still contained in charcoal other than water. The high volatile material content in charcoal briquettes will cause more smoke when the charcoal is burned, this is not good for health and the environment. The content of the volatile matter for each material is different because it is influenced by the volatile substances contained in the material. The pyrolysis temperature also affected to volatile matter content. Fig 4, shows the effect of the temperature of pyrolysis on volatile matter content.

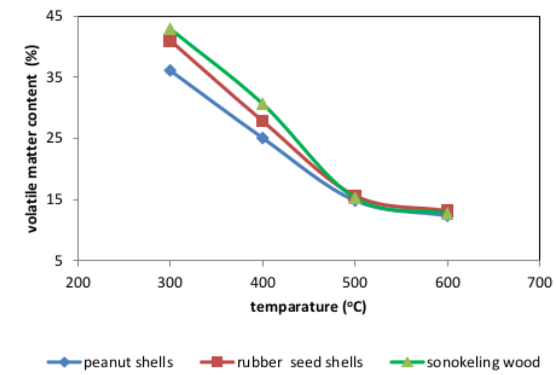

Fig. 4. The effect of temperature on the volatile matter content

It is known (Fig. 4), that the higher the pyrolysis temperature, the lower the volatile matter content. this is due to the higher the pyrolysis temperature, the substances other than charcoal have undergone decomposition and evaporated during the pyrolysis process. The highest volatile matter of 42,91% is found in briquettes charcoal from snorkeling wood at 300°C pyrolysis temperature and the highest, while the lowest volatile mater content of 12,34%% in peanut shells briquettes charcoal.

IV.4. Fixed Carbon Content

The content of fixed carbon indicates the amount of carbon element content that is retained in the briquette and has an influence on the volatile matter and carbonization temperature. The higher the fixed carbon content, the lower the volatile material. Figure 5 shows, the effect of temperature on fixed carbon content.

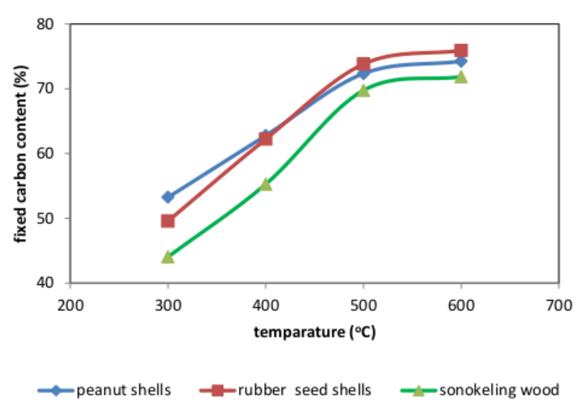

Fig. 5. The effect of temperature on the fixed carbon content

Fig. 5 showed that the lowest fixed carbon value was 44,04 % for the material of snorkeling wood at the temperature of 300°C, while the highest fixed carbon content (75,92%) was from material rubber seed shells at the pyrolysis temperature was 600°C. This is because, the higher the volatile matter, the lower the fixed carbon and vice versa. Likewise, if the ash content is high, the carbon content will be lower.

IV.5. Calorific Value

The calorific value will determine the quality of the briquettes produced. The higher the calorific value, the higher the quality of the briquettes. The calorific value needs to be known to determine the value of the heat combustion produced by briquettes as fuel. The results of the research for the calorific value parameter are shown in Fig. 6.

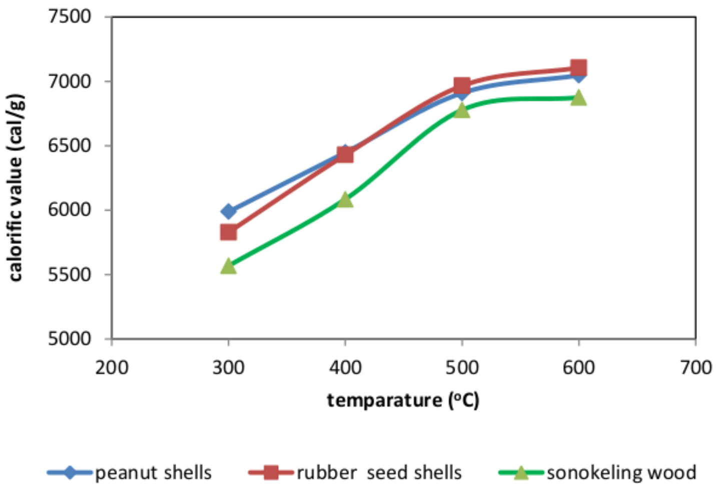

Fig. 6. The effect of temperature on the calorific value

Fig 6. shows that the lowest calorific value was 5567,5 cal/g in briquettes from snorkeling wood at pyrolysis temperature of 300°C while the highest calorific value was 7105,8 cal/g in briquettes from rubber seed shells at pyrolysis temperature of 600°C. The higher the pyrolysis temperature, the higher the calorific value, this is due to the fixed carbon content in the charcoal briquettes. This is because, in the combustion process, carbon is needed which will react with oxygen to produce heat.

The results of this study indicate that at pyrolysis temperatures 600°C, 8% adhesive, the parameter of moisture content parameters, ash content, volatile matter content, and calorific values meet the SNI requirements, while the fixed carbon values near meet the requirements. The characteristic charcoal briquettes resulting in this research compare with SNI presented in Table 1.

Table 1. The Characteristic of Briquette Produced

Characteristic	SNI No. 1/6235/2000	This research		
		Peanut shells	Rubber seed shells	Sonokeling wood
Moisture(%)	≤ 8	7.14	7.4	7.5
Volatile matter (%)	≤ 15	12.34	13.14	12.74
Ash (%)	≤ 8	6.28	3.55	7.90
Fixed carbon(%)	≥ 77	74.24	75.92	71.73
Calorific Value (cal/g)	≥ 5000	7046.838	7105.817	6875.519

V. CONCLUSION AND FURTHER RESEARCH

Increasing the pyrolysis temperature increases the calorific value of the briquettes obtained from the pyrolysis process. Characteristics of charcoal briquettes obtained from pyrolysis temperature of 600°C and 8% adhesive content are moisture content of 7.14 -7.5 %, ash content of 3.55 -7.9%, volatile matter content of 12.34-13.14%, and heating value 6875.519-7105.817 cal/g. This parameter fulfills the SNI requirements, except fixed carbon content of 71.73-75.92% a little less from SNI. Further research is making briquettes to be applied in the community.

IV. REFERENCES

Badan Pusat Statistik, 2016, https://www.bps.go.id/linkTableDinamis/view/id/839

Fessenden, J. Ralp, dan Fessenden, J., 1994, *Kimia Organik*, Edisi ketiga, Erlangga, Jakarta

Sari, I.P. dan Rita S., 2012, "Pemanfaatan Limbah Daun Kering Menjadin Briket", Prosiding Seminar Nasional Teknik Kimia "Kejuangan". H09-1 s/d H09-6 Yogyakarta

Sheth, P.N. and Babu, B.V., 2006, Kinetic Modelling of the Pyrolysis of Biomass, *Proceedings of National Conference on Environmental Conservation"*, 453-458

Suttibak, S., W. Loengbudnark, 2018, Production of Charcoal briquettes from biomass for community use, 8th-TMSE-International Conference of Mechanical Engineering, IOP Conf Series: Material Sciences and Engineering, 297

Syarif Hidayatullah, Rochim Bakti Cahyono dan Muslikhin Hidayat, 2019, Pemanfaatan Limbah Kulit Cacao menjadi Briket Arang sebagai Bahan bakar Alternatif dengan Penambahan Ampas Buah Merah, Jurnal Rekayasa Proses, Vol 13., No. 1, hal 57-64

Titin, SW, 2013. "Karakteristik Briket". Diakses 22 november 2016 dari http://titinkita.blogspot.co.id/2013/03/karakteristik-briket_9029.html

Wei, J., Gefu Liang, James Alex, Thongcao Zhang dan Chunbo Ma, 2020, Research Progress of Energy Utilization of Agriculture Waste in China: Blibiometric Analysis by Citespace, Sustainability, 12, 812, DOI:10.3390/su12030812

Zapalowska, A, Bashutska, U, 2019, The use of agriculture waste for renewable energy production, Proceeding of The Forestry Academy of Sciences of Ukraine

Zubairu, A., Sadiq Abba Gana, 2015, Production and Characterization of Briquette Charcoal by carbonization of Agro-Waste

The Effect of Pyrolysis Temperature on Charcoal Briquettes from Biomass Waste

ORIGINALITY REPORT

11%	8%	5%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	proceeding.rsfpress.com Internet Source	4%
2	Purwiyanta Purwiyanta, C Ambar Pujiharjanto, Rini Dwi Astuti. "The Impact of Financial Inclusion on Economic Growth in Indonesia: Panel Data 34 Province", Proceeding of LPPM UPN "Veteran" Yogyakarta Conference Series 2020 – Economic and Business Series, 2020 Publication	3%
3	repository.its.ac.id Internet Source	2%
4	www.sciencegate.app Internet Source	2%

Exclude quotes	On	Exclude matches	< 2%
Exclude bibliography	On		