Physical Treatment of Oil Palm Shell for Briquette Production as Bioenergy at Remote Area

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Abstract. The daily needs of energy in remote areas, Indonesia, is dominated by biomass waste. The abundant types of biomass waste for heat transfer is empty fruits shell (EFS) of oil palm as briquette. This research discussed a brief analysis of oil palm shell by using physical treatment at different crushing pressure. It was also to examine the adequate size of particle for improving the heating value of briquette. The crushing pressure had a height dimension of 20 cm, as well as the briquette mold with a diameter of 2 cm and a height of 1 cm. The oil palm shell which was applied physical treatment at different crushing pressure of 400 J, 550 J, and 700 J, that resulted in particle size is smaller than 800 µm, 800 µm to 1 700 µm, 1 700 µm to 2 000 µm, and bigger than 2 000 µm. The adequate size of particle for briquette was found to be < 800 µm, which reached the heating value of 20 042.32 J g^{-1} and ash residue of 20 %. This study showed the advantages of oil palm shell briquette by using physical treatment is suitable and sustainable alternative to daily life use in Indonesia.

Keywords: Biomass, renewable energy, waste to energy, zero waste.

1 Introduction

Increasing energy consumption accompanied by depletion of fossil fuel reserves as the main supplier of energy. It is due to an imbalance between the conversion process rate from biomass to fossil which requires millions of years compared to the rate of human energy consumption. It makes fossil fuel as an unrenewable and sustainable fuel. Therefore, a lot of researches were developed to find a sustainable source of alternative energy. Among those who attract attention is the waste of biomass that is categorized as a neutral carbon energy source [1, 2]. Thus, the use of biomass waste as a source of energy can offset the CO_2 emissions generated by fossil fuels.

Waste biomass is mainly produced by commercial plantations such as oil palm, very abundant in Indonesia. In 2017, Indonesia produced 7 071 877 t of fresh fruit palm oil with

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a total area of 12 307 677 ha [3]. The processing of oil palm fresh fruit into oil produces waste such as liquid waste, fiber, and empty fruit bunches [4, 5]. The amount of empty palm oil fruit bunches waste was 6.5 % of the total number of fresh fruit bunches processed, i.e. ammount 1 t [4]. Oil palm shell waste had a heating value of 18 034.56 J g^{-1} [6]. However, the oil palm shell after oil production processing remains as waste [6–8]. In addition, the increasing need for energy and decreasing reserves of fossil fuel resources, has encouraged researchers to develop renewable energy in the form of briquettes [9, 10].

Recently, briquette is one of the energy technologies that is relatively easy to develop and consume by residents in remote areas [11–13]. Some studies have reported on techniques and factors affecting the quality of briquettes [14–16]. The technique of making briquette with both low and high pressure has been conducted to improve briquette performance [17]. In addition, the performance of briquettes is influenced by factors such as ash content and ignition properties. Moreover, one major significant factor is physical properties such as the particle size of the composition briquettes that will affect on briquette utilization in energy requirement. Therefore, the present study determined to investigate the effect of the physical treatment for briquette production on the heating value and ash residue content of palm oil shell waste. In addition, this study measured ignition time and flame burning time of briquette to know the efficiency level of quality briquette. Furthermore, the use of the oil palm shell waste into briquette is an alternative way to reduce much amount of the waste.

2 Materials and methods

Lignocellulosic biomass in the form of an empty fruits shell (EFS) obtained from oil palm shell biomass located in Riau, Indonesia, was used in this study. EFS was dried under the sun for 7 d. The crushing pressure tools (Figure 1) was employed to crush 15 g of dried EFS. The tool height is 20 cm. The briquette mould has a diameter of 2 cm and a height of 1 cm.

Fig. 1. Crushing pressure and briquette tools

The experimental method was explained in detail in Figure 2. The energy pressures applied to treat EFS were 0 J, 400 J, 550 J, and 700 J. Then, the treated EFS was filtered by Testing Sieve Shaker in Bogor, Indonesia. The treated EFS was mixed with water and then pressed 700 J for 1 min with the same equipment to produce briquettes. The sample was heated at 80 °C for 1.5 min in the oven. Briquette was weighed ± 15 g with a thickness of 1 cm and a diameter of 2 cm.
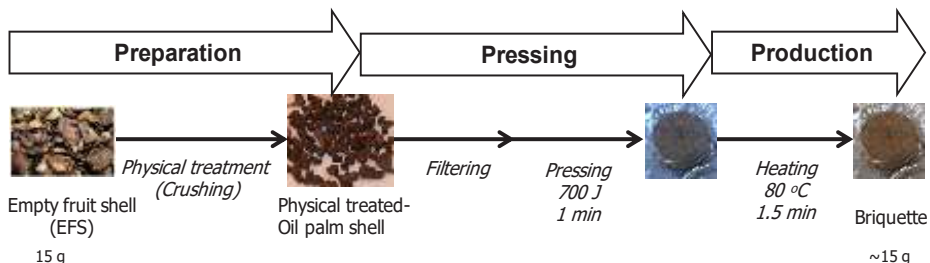
**Fig. 2**. The detail experimental method of briquette by using crushing pressure and briquette tools

The caloric value was analyzed by 1 261 Isoperibol Bomb Calorimeter. The ignition and flame burning time of briquette were also measured. Finally, the percentage of ash residue from combustion briquette was weighed by using the analytical balance.

3 Results and discussion

3.1 Effect of physical treatment on particle size

To evaluate the influence of EFS physical treatment to particle size, the treated EFS was sifted with CBN Testing Sieve Shaker. Figure 3 showed the physical treatment for briquette production on the percentage of particle size at crushing pressure. The physical treatments of 400 J produced 65 % particle size greater than 2 000 µm, 19.05 % had 1 700 µm to 2 000 µm, 9.14 % particle sized 800 µm to 1 700 µm, and 6.91 % smaller than 800 µm, respectively. Increasing energy press given to EFS decreased to percentage of particle size greater than 2 000 µm but increased the percentage of the smaller particles.

These results are similar to previous research that physical treatment produced the compressive energy that affected the particle size i.e. specific surface area [17]. Therefore, the physical treatment at different energy of crushing pressure was sufficient to reduce the particle size of EFS.
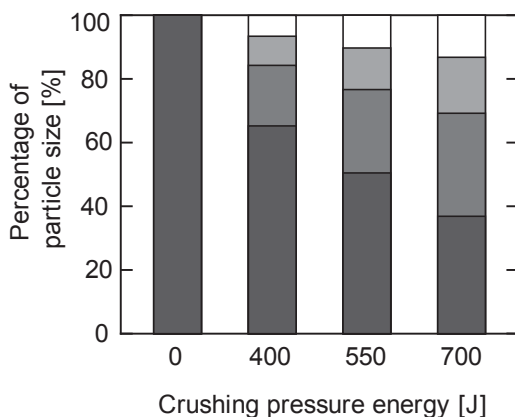
Fig. 3. Percentage of particle size at different crushing pressure of physical treatment (greater than 2 000 µm, 1 700 µm to 2 000 µm, 800 µm to 1 700 µm, and smaller than 800 µm from the bottom).

3.2 Effect of particle size on heating value

To evaluate the influence of the particle size of treated EFS in the briquette on the heating value, the sample was tested in the bomb calorimeter. The heating value of EFS without physical treatment was 18 034.56 J g^{-1}. Table 1 showed the heating value of oil palm shell waste at different particle sizes. The heating value for all EFS samples treated was higher than without physical treatment.

The results was similar to previous research that the particle size of the briquette composition affected the calory briquette value [17], because of heat transfer that occurs among the particles of the briquette. The smaller particle size, the closer of the distance between particles, then the heat transfer would occur through the convection process [18, 19]. Furthermore, these results indicated that physical treatment of oil palm shell biomass using at different crushing pressure was more sufficient to provide energy needs at a remote area.

Table 1. Heating value of palm oil briquette at a different particle size

Particle size (μm)	Heating value (J g^{-1})		
	400 (J)	550 (J)	700 (J)
< 800	18 500.98	18 382.99	20 042.32
800 to 1 700	19 834.84	19 308.28	19 803.58
1 700 to 2 000	19 215.23	19 338.16	19 668.52
> 2 000	19 042.30	18 672.77	20 039.48

3.3 Effect of particle size on ignition time

To examine the efficiency of briquette, ignition time test was applied. Figure 4 showed the ignition time of sample. For EFS not briquette sample showed the fastest ignition time i.e. 46 s. The longest ignition time occurred on the briquette sample which particle size of 1 700 μm to 2 000 μm was 122 s. For briquette sample which particle size < 800 μm, the ignition time was 60 s. The ignition time of briquette that particle size 800 μm to 1 700 μm, and > 2 000 μm were 110 s and 98 s, respectively.

Due to the ignition time was combustion reaction, therefore oxygen were required. In the case EFS not briquette, there were opened space to provide oxygen. As the result, the combustion reaction occurred quickly. It was different from briquettes that particle size > 800 μm. The presence of an empty cavity inside the briquette caused the heat transfer slowly. The pressing step might generate the absence of oxygen in the briquette and remained the loss binding among the particle [7, 16, 19]. For briquette which particle size < 800 μm, the smaller particle size, the larger specific surface area of the particles that can speed up the heat energy during the combustion process through convection. Therefore, particle size < 800 μm was the best briquette among all the samples.
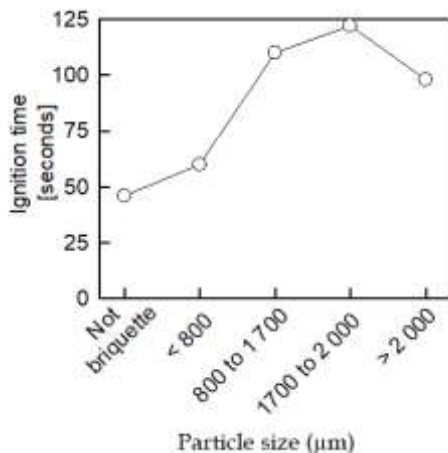
Fig. 4. Ignition time of sample

3.4 Effect of particle size on flame burning time

Determine the efficiency of briquette, the flame burning time was conducted. Figure 5 showed the flame burning time of sample. For EFS not briquette showed the fastest ignition time i.e. 8.67 min. The longest ignition time occurred on the briquette which particle size of > 2 000 μm was 16.67 min. For briquette sample which particle size < 800 μm, 800 μm to 1 700 μm, and 1 700 μm to 2 000 μm were 11.67 min, 13.5 min, 13.5 min, respectively.

These results indicated that the main factor influenced are specific surface area of the particle and the presence of cavity without oxygen content as mentioned above [7, 16, 19]. The linear trend of the results represented the supporting reason of relations between igniton time and the flame burning time due to those main factors. Compared to all treatments, briquette contained particle size < 800 μm was the best briquettes due to fast ignition and flame burning time.
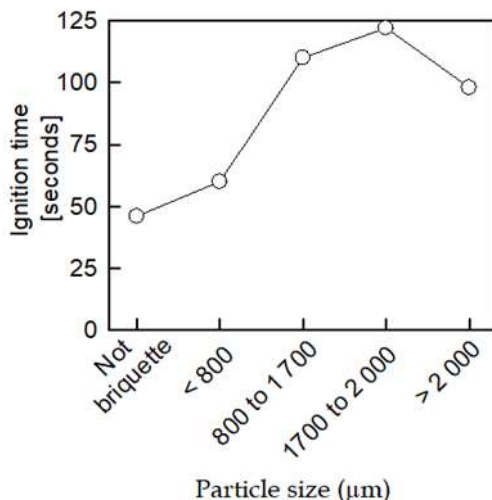
Fig. 5. Flame burning time of sample

3.5 Effect of flame burning time on ash percentage residue

To investigate the effect of flame burning time on ash content residue, the ash residue was weighed after the combustion process. Figure 6 showed the used percentage of original biomass size at the flame burning time. Almost all briquettes had more than 25 % ash residue, except briquettes with a particle size of < 800 μm only 20 % of the total weight of the briquette.

The ash percentage residue refferred that the smaller of particle size and the larger of the specific surface area that can speed up the heat transfer energy during the combustion process and the perfect combustion of briquette almost occurred [7, 16, 19]. These results supported the previous parameters such as ignition and flame burning time. From point of effiency view, the briquette contained particle size < 800 μm was the best and recommended to provide energy at the remote area.
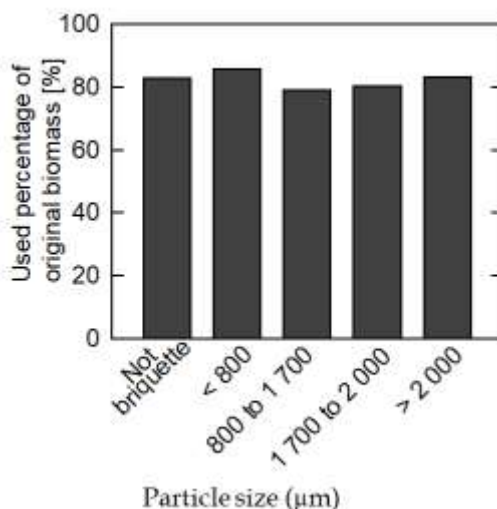

Fig. 6. Use percentage of original biomass at burning test.

4 Conclusion

The oil palm shell which was applied physical treatment at different crushing pressure of 400 J, 550 J, and 700 J, resulted in particle size was smaller than 800 μm, 800 to 1 700 μm, 17 002 000 μm, and bigger than 2 000 μm. The best briquette was found in size of particle < 800 μm, which reached the heating value 20 042.32 J g^{-1}, and ash residue 20 %. However, physical treatment with different crushing pressure showed the higher heating value than the untreated biomass.

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