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Effects of Oil Palm Trunk (OPT), Peat and Coconut Shell Charcoal on the Characteristics of Biomass Pellet

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ABSTRACT

This paper presents an experimental study of mass percentage and pretreatment effect of oil palm trunk (OPT), and peat charcoal on energy parameters of biomass pellet. The density, calorific value, moisture and ash content of OPT biomass pellet has been developed and the experimental conditions in obtaining the energy parameters of OPT biomass pellet are discussed. The physical pretreatment was carried out by finely chopping OPT, peat charcoal, and adhesive and mixed in a predetermined composition. The manufacturing process of OPT biomass pellet was performed, the mass percentage of OPT and peat charcoal were varied. Type of test was performed on biomass pellet include density, calorific value, moisture and ash content. The influences of various parameters on the characteristics of biomass pellet were considered. The increase of mass percentage and pretreatment of peat charcoal has an effect on increasing the density, decreasing the calorific value of OPT biomass pellet, increasing the moisture content, and increasing the ash content of OPT biomass pellet. The mixture of coconut shell charcoal decreasing the density, increasing the calorific value, decreasing the moisture content, and decreasing the ash content of OPT biomass pellet. Biomass pellets from a mixture of OPT and coconut shell charcoal has a calorific value of 6649 cal/g, where the density was 1.15 g/cm^3, the moisture content of 5.6%, and the ash content of 8.9%.

KEYWORDS: *oil palm trunk, peat charcoal, biomass pellet.*

1.0 INTRODUCTION

The use of fossil fuel energy in Indonesia is generally oil, coal and natural gas. Energy is used as fuel for power generation, transportation, industry and others. Energy is classified into non-renewable energy and renewable energy. Non-renewable energy is energy that cannot be renewed; its availability will run out. Non-renewable energy has disadvantages such as limited availability, and can pollute the environment. However, renewable energy is energy that has a lot of availability. This renewable energy is very environmentally friendly. Indonesia has quite a lot of renewable energy sources [1]. One type of renewable energy that is being developed biomass energy.

There are many sources of biomass energy in Indonesia due to the availability of raw materials from the rest of the processing of the plantation and agricultural industry [2]. Densification of biomass (forestry, agricultural and plantation waste) into biomass pellets is one method of developing the function of a resource, increasing the energy content per unit volume, reducing the amount of ash in the combustion residue and increasing heat capacity. An example of biomass energy is biomass pellets.

Pelletization can improve the quality and burning characteristics of biomass. Biomass pellet is the solid cylindrical fuel energy produced by compaction of natural materials such as wood, oil palm bunch, coconut charcoal, and others. Biomass pellets can be used as an alternative fuel for rural community. Research on biomass pellets based on the utilization of palm oil waste has been developed. Characteristic and burning test of biomass pellet from oil palm empty fruit bunches (EFB) and sawdust as renewable alternative fuels have been carried out. The higher of the percentage of sawdust mixture it will increase the water content, volatile matter content, and density value will be increase. However, the ash content, bond carbon value, and calorific value decreased [3].

The improvement of biomass pellets characteristic has been carried out with the addition of coconut shell charcoal. The variations in the addition of shell carbon percentage affect the heating value of the palm oil bio pellets produced. The best variation of the formation of palm wood bio pellets with carbon addition from coconut shell charcoal is in variation of adding coconut shell charcoal 30% [4]. Lamanda et al (2015) [5] found that the characteristic of bio pellets based on the composition of oil palm trunk particle and Laban wood charcoal with different type of adhesive as a renewable fuel. The composition of oil palm and Laban wood charcoal

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and type of adhesive was significantly affected the calorific value of bio pellets. The other values such as moisture content, ash content, volatile matter content and fixed carbon content was not significant effect [5]. Bantacut et al. (2013) [6] was studied about the quality of bio pellets from mixture of charcoal and palm kernel shells. Based on the chemical and physical properties and the combustion characteristic, bio pellet of palm shell that contain 80% of palm shell and 20% of palm shell charcoal gave the best quality [6]. Rohamtullah et al. (2014) [7] was studied about the moisture content, unit density, ash content, and calorific value of OPT biomass pellets. The combustion profile bio pellet seemed to be unaffected by the bark content [7].

The quality of bio pellet from oil palm trunk waste with different size of particle and adhesives has been studied. The type of adhesive and the size of the particle were not significant effect on the value of the moisture content, ash content, volatile matter content, and bonded carbon as well as the interaction of these factors. However, this parameters very significant effect on calorific value and the second interaction factors [8]. The quality of bio pellet from OPT waste and sawmill waste has been investigated. Differences in the percentage of OPT waste and wood sawing waste as the material have been found to have an effect on the quality of bio pellets [9].

The upgrading of bio pellets characteristics of EFB with the addition of oil sludge and co-firing has been investigated. The effect of adding oil sludge as co-firing results in the calorific value of the bio pellets is lower than the calorific value of EFB. This is due to the high calorific value of the oil sludge lower than calorific value of EFB. Pre-treatment needs to be carried out to reduce the ash content of EFB biomass. The addition of adhesive is needed to be studied to improve the mechanical properties bio pellet without reducing its calorific value [10]. Characterization of mixed biomass pellet made from oil palm and para-rubber tree residues has been investigated. The half mixed of two biomass fuel pellet can significantly improve characteristics of pure biomass pellet. Especially, the additional raw biomass, which has a higher quality than the own one. The ignition temperature and the maximum weight loss rate were decreased, whereas the burnout temperature was increased [11].

Characterization of biomass pellet made from solid waste oil palm industry has been studied. Oil palm frond is easily molded to be bio-pellet than other materials. The key factor in producing bio-pellets depends on the type and size of material. Based on the water content, ash content, density and calorific value, then oil palm mesocarp fiber bio-pellet was pressed at 200 and 250°C as the best formula [12]. Difference in the sieve or particle size of the bio-pellet have a significant effect on the value of the compressive strength, moisture content, ash content, and calorific value but do not have significant effect on the density value of bio-pellet [13]. Optimal treatment occurred at the particle size 20 mesh bio-pellets with the addition of 20% tapioca adhesive. Several studies have shown that biomass pellet materials and pretreatment were parameters that need to be studied to improve the quality biomass pellets as an alternative fuel.

In this study, biomass pellets were made from a mixture of OPT particles and peat charcoal. The mass percentage of OPT and peat charcoal were varied. Pretreatment was carried out on OPT fiber and peat charcoal by soaking peat water and coconut shell charcoal for various time. Materials that have been pretreated were added with adhesive (tapioca). Biomass pellets were produced by using a pelletizer machine. Density, calorific value, moisture and ash content of biomass pellets were tested to determine the effect of mass percentage and pretreatment of biomass pellet materials.

2.0 METHODOLOGY

2.1 Materials

This research conducted an experimental study of the mass percentage and pretreatment effect of OPT and peat charcoal on energy parameters of biomass pellet. The OPT is very potential to be used as a biomass material because of its ash contains. PCC was investigated in this research because it contains carbon which is useful as an alternative fuel. The OPP has the potential to be developed because peat content has the potential to be studied because it contains elements to improve the biomass performance. Biomass pellet material consists of OPT powder (OPT), OPT powder and peat charcoal (OPP), peat charcoal mixed with coconut shell charcoal (PCC), and OPT powder mixed with coconut shell charcoal (OPC). OPT powder was produced by using a conventional crushing machine. The peat charcoal used is plant residue that has been soaked in peat water and this material was dried. Coconut charcoal is produced from incomplete combustion of coconut shells. Biomass pellet materials were obtained from Riau Province, Indonesia.

Table 1 shows the biomass pellet material and the mass percentage of the biomass pellet. The OPT powder was produced from the process of chopping palm trunks. The OPT collected were replanted OPT, which was more than 20 years old. The chopped palm trunk was then sieved with a mesh size of 20. Palm trunk powder produced from the sifting process was used as material for biomass pellet. The coconut shell charcoal was chosen as a mixing material for biomass pellet because this material has a high calorific value.

2.2 Method

Figure 1 shows the process of each prepared materials of biomass pellet. The OPT powder and coconut shell charcoal were mixed with charcoal in peat water that were soaked for 24 hours. The peat water used for pretreatment of biomass pellet materials with pH is equal to 6.6. After pretreatment, the materials were mixed with adhesive (tapioca). Tapioca content used was 20%. OPP, PCC, and OPC materials, each obtained by stirring with mixing blender machine.

Table 1: Mass percentage of biomass pellet materials

Type	Mass percentage of bio-pellet		
	OPT powder	Peat charcoal	Coconut shell charcoal
OPT	100%	0%	0%
OPP-I	25%	75%	0%
OPP-II	50%	50%	0%
OPP-III	75%	25%	0%
PCC-I	0%	25%	75%
PCC-II	0%	50%	50%
PCC-III	0%	75%	25%
OPC-I	25%	0%	75%
OPC-II	50%	0%	50%
OPC-III	75%	0%	25%

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(a) Mixing process


(b) Stirring process


(c) Molding process


(d) Pellet product

Figure 1: The process of prepared materials of biomass pellet


(a) OPT


(b) OPP


(c) PCC


(d) OPC

Figure 2: Pretreatment of materials from biomass pellet

The stirring process was carried out for 5 minutes. The materials of biomass pellets and adhesives that have been mixed were prepared for the molding process into a cylindrical shape. The pellet shape has average diameter of 6 mm and average length of 20 mm (Figure 2).

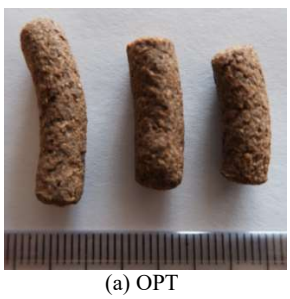
Biomass pellets were produced using conventional portable molding machine. The materials were pressed at a temperature of 220°C. The production process of biomass pellets was carried out continuously where the material passes through a die plate and a roller press. The biomass pellet produced from the machine is then prepared for testing. Figure 3 shows samples of biomass pellets with types of OPT, OPP, PCC, and OPC. The energy quality of the biomass pellet was tested with several parameters.

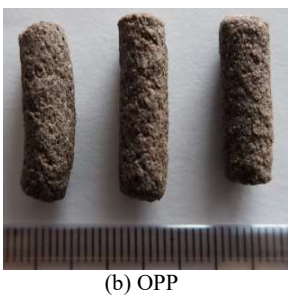
The tests carried out were testing of density, calorific value, moisture content, and ash content. The density of the biomass pellet is weight by volume of the biomass pellet. Density test method of biomass pellet accordance to ASTM D4784 standard. The calorific value measurement determined by bomb calorimeter. Calorific value tested accordance to ASTM D1989. The moisture content was measured accordance to ASTM D3173. Measurement of the ash content was carried out by burning the test sample in a furnace at a temperature of 750°C for 4 hour.

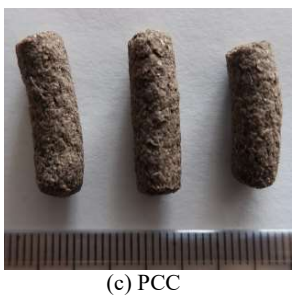
3.0 RESULTS AND DISCUSSION

3.1 Density

The density value of biomass pellet affects the process of transporting and storing pellets [14]. Figure 4 shows the density of biomass pellet with different mass percentages of mixed materials and pretreatment. Biomass pellets containing OPT material showed a higher density than other biomass pellets. The presence of peat charcoal content, which increase the density of OPT biomass pellets. That was due the presence of high concentrations of organic and ferrous in peat water affects the mass of charcoal. Pretreatment of OPT biomass pellet on peat charcoal increases the density of OPT biomass pellet about 1.5%. The density of the biomass pellet mixture of coconut shell charcoal was lower than the density of biomass pellet containing OPT powder. The density of coconut shell charcoal was used 24% lower than the density of OPT. Pretreatment with peat charcoal increase the density of biomass pellet with a mixture coconut shell charcoal. The more mass percentage of peat charcoal to coconut shell charcoal, the density of biomass pellets also increase.


(a) OPT


(b) OPP


(c) PCC

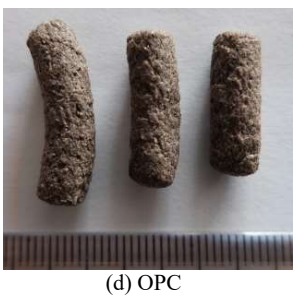

(d) OPC

Figure 3: Several types of test sample of biomass pellet

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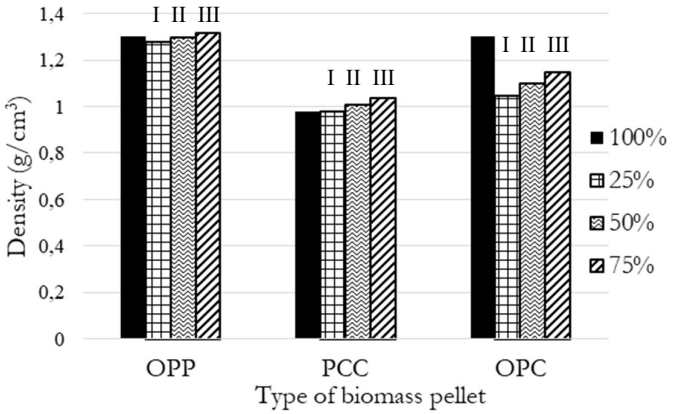

Figure 4: Density of biomass pellets

Pretreatment of coconut shell charcoal on peat charcoal increased the density of biomass pellets from coconut shell charcoal about 6.1%. Based on the macroscopic observation, it can be seen that the physical condition of the type of biomass pellet produced was cylindrical, there was no brittleness and fracture on the pellets. This means that all type of biomass pellets were efficient during transportation and storage.

3.2 Calorific Value

Figure 5 shows the effect of mass percentage of oil palm trunk waste, pretreatment with peat charcoal contaminated with peat water, and coconut shell charcoal on the density of biomass pellets. The calorific value of biomass pellet was influenced by the mass percentage of coconut shell charcoal.

The addition of coconut shell charcoal to OPT was able to increase 7.1% to 52.3% calorific of biomass pellets. It can be seen that the OPC bio-pellet at 75% of the mass of coconut shell charcoal has a higher calorific value than other types of biomass pellets. The calorific value of coconut shell charcoal affects changes in the calorific value of OPT bio-pellet. The calorific value of coconut shell charcoal was relatively high, which more than 4.1 kcal/g [14]-[17]. Therefore, this value was able to increase the calorific value of the OPT bio-pellets significantly. However, the pretreatment factor with peat charcoal has not shown a significant effect. This was shown from the calorific value of OPP and PCC in Figure 1. The contents of peat water have not been able to increase the calorific value of OPT and coconut shell charcoal. The calorific value of OPT biomass pellets decreased about 20.3% due to pretreatment with peat charcoal. This indicates that pretreatment with peat charcoal soaked in peat water causes decrease in the bound carbon content of the bio-pellet.

3.3 Moisture Content

Figure 6 shows the effect of mass percentage of biomass pellets on moisture content. The effect of charcoal on OPT biomass pellets increased 38% moisture content of OPT bio-pellets. However, increasing the mass percentage of peat charcoal to OPT bio-pellets decreased the moisture content to 18%. The increase in the percentage of peat charcoal on OPT biomass pellets reduces the moisture content of the biomass pellets. The moisture content decreased due to the increasing mass content of coconut shell charcoal in bio-pellets with peat charcoal treatment. Moisture content in bio-pellet with 25% coconut shell charcoal was 37.8% lower than the OPT biomass pellet. Increasing the percentage of coconut shell charcoal mass resulted in a decrease in the moisture content of the biomass pellet. An increasing in the percentage of peat charcoal and a decrease in coconut shell charcoal can reduce moisture content about 25.5%.

The moisture content of coconut shell charcoal increased due to pretreatment with peat charcoal. However, the addition coconut shell charcoal decreased the moisture content of the OPT bio-pellet. The coconut shell charcoal material, which mixture the OPT powder reduced the moisture content of the biomass pellet. Moisture content of OPT bio-pellet with a mixture of 75% coconut shell charcoal was reduced to 31.7%. This different moisture content indicates that the content of the biomass pellet material and pretreatment affects the water contained in the bio-pellet. The water content affects energy parameter such as the calorific value of bio-pellets.

3.4 Ash Content

Figure 7 shows the ash content of the biomass pellet type using OPT, peat charcoal, and coconut shell charcoal. Pretreatment with peat charcoal causes an increase in the ash content of the biomass pellet. However, the coconut shell charcoal material causes a decrease in ash content of OPT biomass pellets. The ash content of biomass pellets of the OPT mixed with 25% peat charcoal increased about 21.2%. However, increasing the mass percentage of peat charcoal decreased the ash content, but the water content was still higher than the bio-pellet containing 100% of the OPT.

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3.5 Ash Content

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The increase in ash content due to the effect of pretreatment also occurred in coconut shell charcoal. At a low mass percentage of coconut shell charcoal, 25%, mixed with 75% peat charcoal increases the ash content of the coconut shell charcoal about 72%. However, the ash content decreased due to the addition of coconut shell charcoal. The ash content in a mixture of 75% of coconut shell charcoal and 25% of peat charcoal decreased about 19%. The ash content of OPT decreased when mixed with coconut shell charcoal. In a mixture of 25% of the mass of coconut shell charcoal in a mixture of OPT powder, the ash content was reduced 37.2%. The ash content of OPT increased due to the addition of coconut shell charcoal, but the ash content was below the ash content where the mass content was 100% of the OPT.

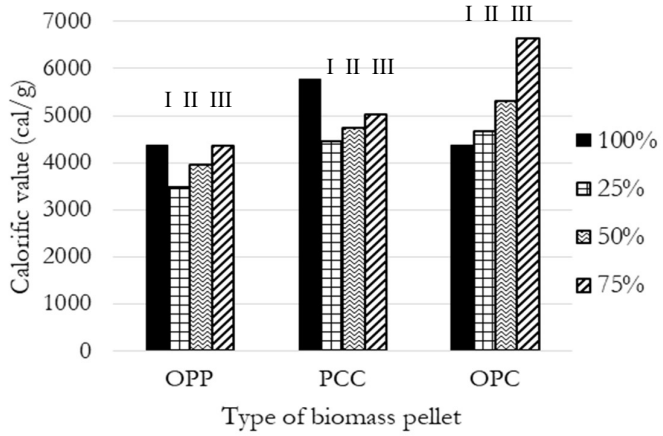

Figure 5: Calorific value of biomass pellets

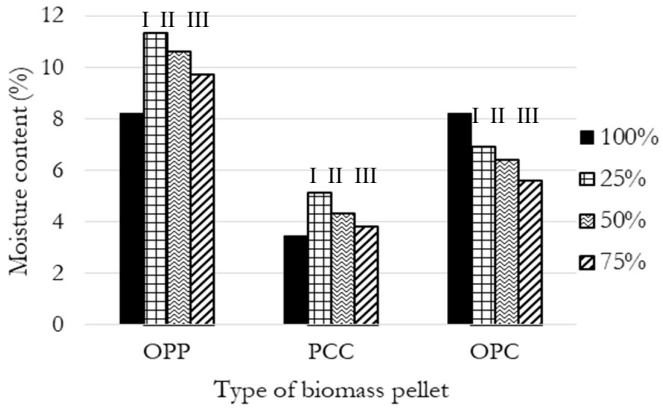

Figure 6: Moisture content of biomass pellets

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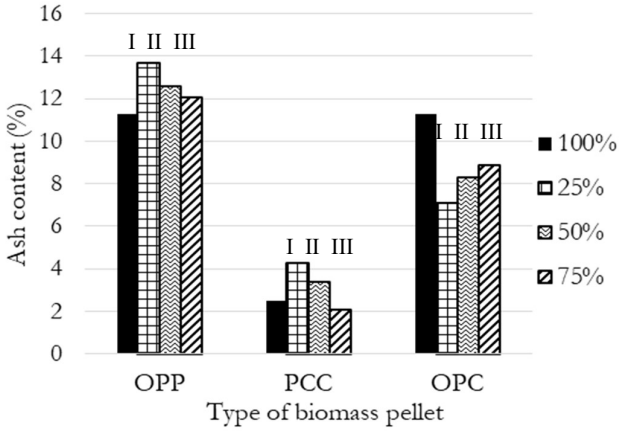

Figure 7: Ash content of biomass pellets

4.0 CONCLUSION

Effects of mass percentage and pretreatment of OPT and peat charcoal on density, calorific value, moisture and ash content of OPT biomass pellet were carried out in this study. The increase of mass percentage and pretreatment of peat charcoal has an effect on increasing the density, decreasing the calorific value of OPT biomass pellet, increasing the moisture content, and increasing the ash content of OPT biomass pellet. More, the mixture of coconut shell charcoal decreasing the density, increasing the calorific value, decreasing the moisture content, and decreasing the ash content of OPT biomass pellet. The biomass pellets from a mixture of OPT and coconut shell charcoal has a calorific value of 6649 cal/g, where the density is 1.15 g/cm^3, the moisture content is 5.6%, and the ash content is 8.9%.

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