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Assessment of combustion behaviour of carbonize bio-briquette wood residue under different pressure and particle size

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Assessment of combustion behaviour of carbonize bio-briquette wood residue under different pressure and particle size

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Abstract. The effect of particle size distribution and compaction pressure of wood residues briquette was investigated. Starch was used as a binder. Concerning that the wood residues have valuable content namely lignin and cellulose, the wood have a high possibility to be modified as a biofuel. In this study, the wood residues (iron and gelam woods) were treated by drying, milling, and carbonization at 500 °C. The ratio between carbonize wood and binders was 20% of the weight. The briquette was manufactured at room temperature with different compaction pressure (10, 12, and 15 MPa) and particle size (40, 50, and 60 µm). The results revealed that the carbonize wood and the inorganic binder performed a good combination. The characteristics of wood residue briquette (WRB) during the first 50 min were higher burning temperature (180°C) for the 60 µm of particle size and 15 MPa of compaction pressure. The lowest water absorption value was 0.25% for the compacted at 15 MPa. Burning rate decreased follows the briquette compaction pressure (3.1 to 2.3 g min^{-1}).

Keywords: iron wood, gelam wood, particle size, compaction pressure, combustion rate.

1. Introduction

Since the depletion of fossil fuel and air pollution become global issue, had increasing the researchers make the effort move to the biomass sources as an alternative fuel. Biomass consist of organic materials where it is rich of energy resources. Basically, biomass seems to be unused material because it is more possibly to be thrown away into a waste. However, with the technology, the waste can be transformed into fuel. Biomass has gained in concert of the widely used sources of renewable energy. Therefore, if biomass is employed as another fuel it will reduce the consumption of fuel and also reduce air pollution [1,2]. Teixeira *et al.* [3] mentioned that biomass become the emerging alternatives for the diversification of energy resources. Biomass can be also directly converted into fuel [4] with the low risk and low capital required renewable energy source. Among various kinds of biomass, wood residue is one promising sources. Wood residue contained high cellulose and lignin, which is high possibility to be modified as a biofuel.

In this regard, Indonesia is a country that has been blessed with huge forest area. Simanguncong *et al*. [5] noted that 50.4% of forest residue generated from harvesting and 49.8% from wood processing can be converted into bioenergy. The utilized of wood biomass for energy alternative is relatively small and confined to residential firewood and a few industrial sector. This huge wood biomass resource ought to not be considered as a low economic cost resource since it can be changed over into bioenergy through different technologies and ended up one of important energy sources in Indonesia. Nanda *et al.* [6] mentioned that wood residue biomass contained 20 -40% of hemicellulose, 35-55 % of cellulose, 10 – 25% of lignin. Various technology has been employed to convert wood residue biomass into secondary energy sources via combustion [7,8], pyrolysis [9,10] and gasification [11,12]. Among these, combustion and gasification are the important technologies for that kind of fuel which have control of greenhouse gas problem. However, a large amount of energy is consumed for processing when the combustion and gasification is applied. Also, these technologies are often uncompetitive in comparison with other gasification technology [12].

Recently, pyrolysis become attracted technology to convert wood biomass into fuel. Xin et al. [10] concluded that the temperature and catalytic loading were the major factors influencing the pyrolysis product. In other side, the catalytic used required the high temperature for complete conversion into the intermediate compounds. Therefore, this technology closely related to high energy consumption and considerable production costs.

Oladeji [13] suggested that while wood residue biomass can be directly used as fuels, they are in any case not straightforwardly appropriate clearly since of their uneven nature, bulkiness, and having lest energy density; characteristics that make them troublesome to handle, store, transport, and utilize in their raw material; consequently, there is need to subject them to conversion processes. One of the most potential technology solution for these problems is the application of briquetting technology. Several research work have conducted the briquetting biomass such as corncobs [14], bagasse and coffee [15]. Their process was trough to the carbonized process and the results were showed that the carbonization biomass before briquetting can improve the properties of briquette. Briquetting technology present an efficient densification process that produces a unvarying fuel, improve the energy density and reduce the transport and handling cost of the wood residues biomass. Recently, view studies have evaluated the possibility of utilizing different residues biomass such as investigated the properties of cotton stalk and wood sawdust [16]; briquetting of vegetable market waste and saw dust [17]; production and characterization of coffee-pine wood residue briquettes [18]. The results of these studies revealed that the produced briquettes change the physical and combustion properties of the briquette, comparatively replace charcoal and wood that are deforestation and erosion.

Based on the above discussions, the typical wood residue biomass, especially growth in wet land areas, ulin wood residue (UWS) and gelam wood residue (GWS) were selected as a research object. Therefore, to obtain the suitable product, the physical properties and combustion behavior are important to be elucidated. Thus, the purpose of this study is to investigate the effect of particle size distribution and compacting pressure on the combustion behavior as well as combustion rate of carbonized wood residue briquettes with the inorganic binder agent.

2. Materials and methods

2.1. Raw materials

The wood residues utilized in this study were iron wood residue and gelam wood residue. The raw materials were collected form South of Kalimantan, Indonesia. The device was a briquetting machine (piston press type) laboratory scale. The materials were manually drying with lower moisture content of <15% dry basis. The proximate and ultimate analyses of the feedstock was obtained by our research group [19,20].

2.2. Biomass briquette preparation

The feedstock was carbonized at 500°C using electric furnace. The feedstock were weighed (15 gram) according to the required proportion and mixed with fixed concentration of inorganic binder (20%). The compaction pressure were varying of 10, 12, and 15 MPa. The particle size distribution was set of 40, 50, and 60 µm. The inorganic binder was prepared by mixing with the water and boiling them to obtain the proportion binder. 20 % of binder was mixed with the carbon feedstock. The mixture was then fed into the cylindrical mould and briquettes were produced at the Mechanical Engineering Laboratory, ULM. The method included the utilized of high pressure with a residence time of approximately 5 min to avoid the spring back impact of the biomass materials. The briquette produced was ejected from the mould and dried (sun drying) for 3 days to remove the water inside it and keep at room temperature.

3. Results and discussion

3.1. Effect of compaction particle size distribution on combustion behavior

Figure 1a, **Figure 1b**, and **Figure 1c** illustrated the combustion behavior of biomass briquette in the different particle size and compaction pressure. From the **Figure 1** it was found that the different of particle size distribution were no significantly effects on the combustion behaviour of the briquette products. The particle size distribution has little effect, the higher combustion time was 50 min. The particles size have more effect on the mechanical strength and density which is depend on the strength of inter-particle bonds [21]. However, the compaction pressure has great effects on the combustion behaviour of the briquette products. The higher compaction pressure (15 MPa) contributed to increasing the combustion temperature of 180 °C followed by 12 and 10 MPa with the combustion temperature of 140 °C. This result agreed with previous study by Nurek *et al.* [22] mentioned that the higher combustion temperature allows to obtained briquettes of higher compaction pressure or density.

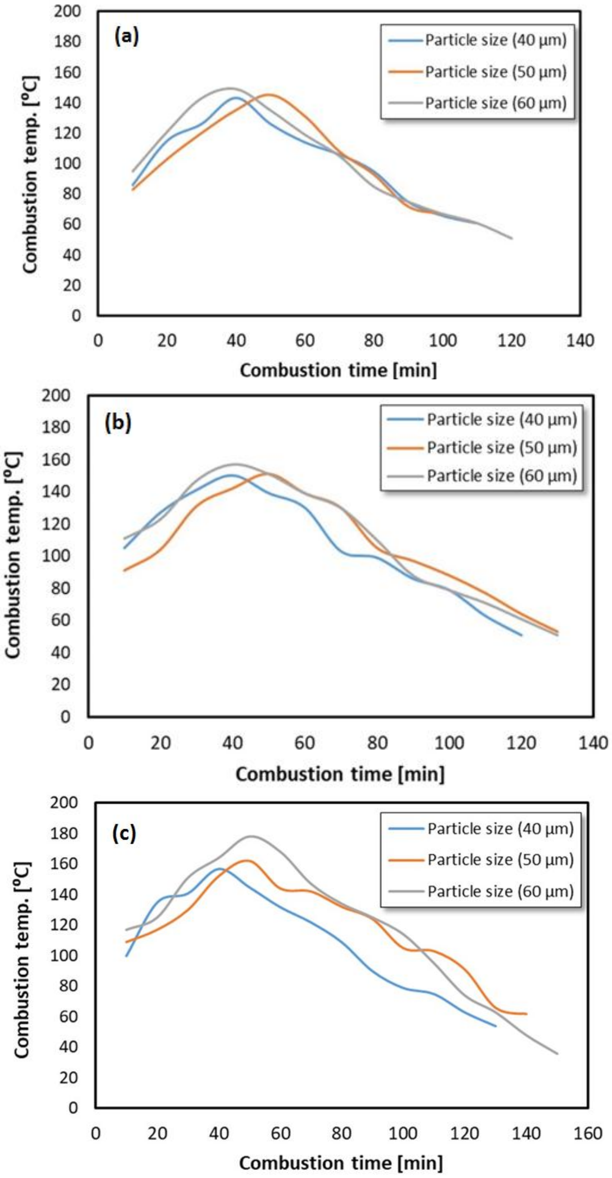

Figure 1. Combustion behaviour of biomass briquette with the different particle size distribution and compaction pressure **(a)** 10 MPa, **(b)** 12 MPa, and **(c)** 15 MPa

3.2. Combustion rate of briquette products

The combustion rate of the briquette product is shown in **Figure 2**. The increasing compaction pressure has effect on the reducing porosity thereby reducing air circulation and hence reducing combustion rate [23]. The combustion rate was obtained by observing the mass changes recorded on mechanical balance and stop watch.

As shown in **Figure 2**, combustion rate for each samples of the briquette decreased as the compaction pressure increased. It might be due to reduction of air gap between particles of briquette increased in the high compaction pressure. The lowest combustion rate was observed at 15 MPa of 0.25 g min^{-1}. This result was higher than previous work by Faizal *et al.* [23] and Sasongko [24] who observed that the combustion rate of briquette palm oil mill residue was 0.08 g min^{-1}, and 1.3 l s^{-1} for biodiesel produced from waste cooking oil. It might be due to the effect fibrous structure of the raw materials and the viscosity in case of waste cooking oil.

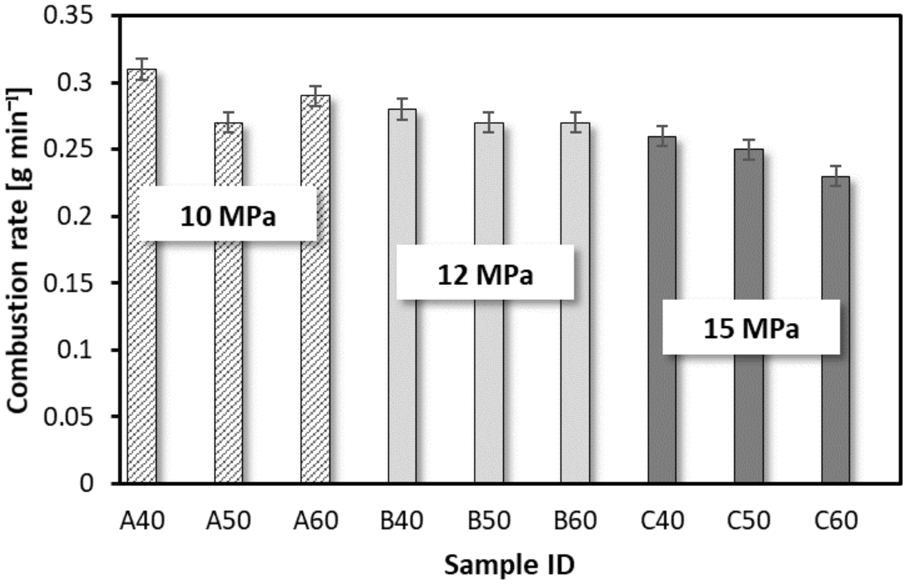

Figure 2. Combustion rate for each briquette samples with the different of compaction pressure

3.3. Mass loss of the briquette

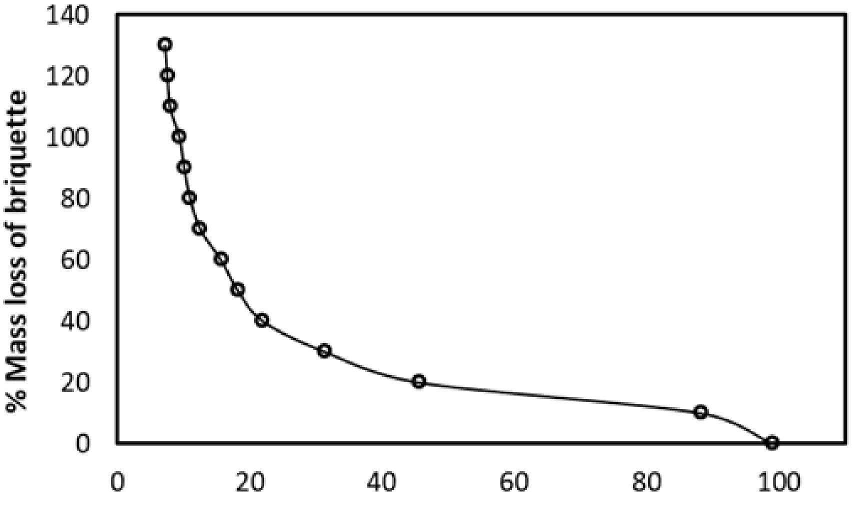

Figure 3. Combustion rate of briquette sample

Figure 3 represents the mass loss of the briquette product during the variety of the combustion time. The results reported that at the beginning of 0 – 20 s, the main loss took please it was associated with their morphological characteristics. That was indicated moisture content was moved out from the briquette samples. As shown in **Figure 3** above the combustion time was recorded as soon as the flame on contact with the briquette, which the change in mass recorded at 10 s interval. The three distinct phase can be described which are; the ignition phase, steady-state flaming combustion, and char combustion.

4. Conclusion

The combustion behaviour of bio-briquettes fuels made from iron wood residue and gelam wood residue and their agglomerates using inorganic binders were investigated. The different particle size had no significant effect on all combustion behavior investigated on the briquette produced. An increase in the compaction pressure has affected the combustion time achieved 180 ^{o}C at 50 min of combustion time. The combustion rate decreased while the compaction pressure increased, it was found the lowest combustion rate of 0.25 g min^{-1}. The moisture content moved out from the briquettes sample at the beginning of 0 – 20 min combustion time it signed by mass loss of the briquette products.

5. Acknowledgement

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6. References

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