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Influence of composition and compaction pressure on the physical quality of wood residue and bottom ash mixture briquettes

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Abstract. Woody biomass is briquette-densified to enhance its physical and mechanical properties during handling and storage. However, Limited study on the physical consistency of briquettes made from wood biomass and bottom ash blends has been carried out. The bottom ash used in this study is a residue from burning coal for the powerplant. The physical quality was evaluated for three different compositions (70:30, 50:50, and 30:70). The piston press type machine (laboratory scale) was employed to produce a briquette. This work aims to evaluate the effect of mixing ratio (wood residue and bottom ash) and compaction pressure on the physical quality (water content, ash content, VM, calorific value) and combustion behavior. The compaction pressure was varied between 100 kg/cm² and 150 kg/cm². The result revealed that the compaction pressure affected the physical quality of the briquette. Lower moisture content (MC), ash content (AC), and calorific value (CV) were obtained at the higher compaction pressure. The moisture content of 1.6% was better for the wood residue and bottom ash mixture's compaction pressure. The calorific value of briquette ranged from 5200 kal/g to 5700 kal/g. In conclusion, the combination of low-cost and abundant forest biomass mixed bottom ash available with wood biomass could lead to better physical quality and help meet the demand for the briquette in the future.

Keywords: wood residue, compaction pressure, physical quality, bottom ash, briquette.

1. Introduction

Agricultural waste (such as wood residues) accounting for nearly 40-60% of crops produced in the form of leaves, stems, and other unused parts during the harvesting and processing of crops [1,2]. Biomass is made up of organic materials rich in energy content. Biomass fuels such as wood have substituted coal in many countries for small domestic stoves to decarbonize and because it is also a convenient option. Nonwoody waste, such as waste materials and agricultural waste, is another choice [3]. Briquettes made from pressed wood residue are typically readily obtainable in supermarkets and are often found in smokeless areas. Similarly, In countries like China, India, Africa and Northern Europe, briquettes are used in small stoves for waste farming materials such as wood, straw and bagasse [4–9]. In reality, the use of these low grade biomass fuels has been growing more widely in recent years. The production of wood residue briquettes and bottom ash, which could be alternative fuel to wood logs, is listed in this article. The life cycle effect of wood-based domestic fuels is



significantly lower than that of traditional fuels. The feedstock is a by-product that requires no additional land or effect on forest resources [6–8].

Domestic fuel consumers have historically been connected to charcoal in low-income countries, especially in urban areas, because of its affordability and convenience [10]. Simanguncong et al. [11] It noted that 50.4% and 49.8% of forest residue derived from harvesting can be transformed into bioenergy from wood processing. This huge resource of wood biomass should not even be considered a reasonable resource, as it can be transformed through various technologies into bioenergy and has become one of Indonesia's primary energy sources. Nanda et al. [12] reported that hemicellulose (20-40%), cellulose (35-55 %), lignin (10 – 25%) were included in the wood residues biomass. Various technologies have been used to transform biomass from wood residues into secondary energy sources by combustion [13,14], pyrolysis [15,16] and gasification [17,18]. Combustion and gasification are the efficient technologies for this form of fuel that regulate greenhouse gases.

Pyrolysis has recently become a technique for turning wood residues into fuel. Xin et al. [16] It concluded that the critical factors affecting the pyrolysis product were temperature and catalytic loading. On the other hand, the high temperature needed to be fully converted into the intermediate compounds by the catalytic used. High energy usage and high production costs are also closely related to this technology.

Several research studies, such as corncobs, bagasse and coffee have carried out the briquetting biomass [20,21]. Their method was via the carbonized process, and the results showed that before briquetting, the biomass of carbonization would increase the briquette properties. Briquetting technology provides an effective process of densification that produces an invariable fuel, increases energy density, and reduces the cost of transporting and handling biomass residue of wood. The use of different raw material ratios significantly affects the thickness and impact strength of briquettes. The addition of bottom ash leads to an improvement in briquettes' density, while wood residue presence increases their compressive power.

Based on the above discussions, the typical wood residue biomass and bottom ash were selected as a feedstock. It seems that bottom ash is huge in particle diameter and porous in form. [21]. In a power station, boiler, furnace, or incinerator, bottom ash is part of the combustion's non-combustible residue. It has historically applied to coal combustion in an industrial sense and contains traces of fuels embedded during its process in forming clinkers and sticking to a coal-burning furnace's hot sidewalls. Bottom ash (ba) grinding results in a decrease in pores and an increase in its reactivity. While products from bottom ash have now been recognized as a valuable resource for electricity. Bottom ash (ba) has not been sufficiently investigated in Indonesia as a source of renewable energy; therefore, this research looks at the suitability of using bottom ash mixed wood residue to produce solid bio-fuel by varying the composition and compaction pressure on the physical quality as well as combustion behavior.

2. Materials and Methods

2.1. Feedstock

Feedstock were collected from Tanjung, South of Kalimantan, Indonesia. In this research, the press briquette machine lab scale was developed. Raw material were dried manually with lower moisture content of about 15% dry basis.

2.2. Briquette preparation

Wood residues was carbonized using electric furnaces at 500⁰C, and decided to weigh at a fixed concentration according to the proportion required and blended with the inorganic binder. The compaction pressure ranged from 100 and 150 Kg/cm², respectively. As expected, the particle size was obtained by the sieving process. The acquired particle size is 50 μm. The inorganic binder was prepared to obtain the proportion binder by blending with the water and boiling them. With the carbon feedstock, 5% of the binder was mixed. The raw material mixture was then placed into the cylindrical mold, pressed, and briquettes were made. The compaction pressure between 100 and 150 kg/cm² was

set and variety of composition were made of 70 WB:30 BA (A1 and B1), 50 WB:50 BA (A2 and B2), 30 WB: 70BA (A3 and B3), respectively. In order to avoid the spring-back effect of biomass materials, the process included high pressure with a residence period of about 5 minutes. To minimize the water and keep it at atmospheric temperature, the formed briquette was released from the mold and dried for 3 days (sun drying).

2.3. Analytical Method

The details of the analysis developed in this study are presented elsewhere [22]. Briefly, MC, VM, and AC were calculated based on the dry weight of the sample. After all of the experimental runs, briquette products were analyzed, and the results were tabulated in Table 1. Using an automated calorimeter according to the ASTM standard, the calorific value (CV) of the briquette was calculated.

3. Results and discussion

3.1. physical quality of briquette

The physical quality of the briquette product obtained in this study are tabulated in Table 1.

Table 1. physical quality of briquette sample with variation of the compaction pressure

Compaction pressure [Kg/cm ²]	Sample ID	Composition		Moisture content (MC) [wt%]	Ash Content (AC) [wt%]	Volatile matter (VM) [wt%]	Calorific value (CV) [Kal/g]
		Wood biomass	Bottom ash				
100 Kg/cm ²	A1	70	30	2.38	18.49	14.22	5744.46
	A2	50	50	2.16	18.62	14.16	5593.85
	A3	30	70	2.02	18.94	14.09	5462.04
150 Kg/cm ²	B1	70	30	2.27	15.81	14.46	5578.02
	B2	50	50	1.81	16.08	14.37	5397.88
	B3	30	70	1.66	16.29	14.31	5283.23

The table above found that the compaction pressure differences were no significant effects on the briquette products' physical properties. For each sample, the water content is around 2% by weight. The study sample's water content is showed on the SNI standard No. 01-6235-2000, with a maximum water content of 8% by weight. The ash content results were not included in the SNI standard in all samples in this analysis. The volatile matter was lowest than the standard, less than 15wt%. The composition also showed a small effect on the physical properties of the sample. Adding the bottom ash was not a significant effect of all aspects. For instance, the calorific value was higher at the lower compaction pressure. The calorific value ranged from 5282 to 5744 kal/g was higher than the SNI standard (5000 kal/g). The highest of wood biomass (70%) and lowest bottom ash (30%) showed the highest calorific value of 5744.5 kal/g.

3.2. Temperature profile of the briquette product

The temperature profile of the briquette product is shown in **Figure 1**. The increasing of the holding time has effect on the combustion temperature. The maximum combustion temperature was obtained at 50 min and decreased slowly.

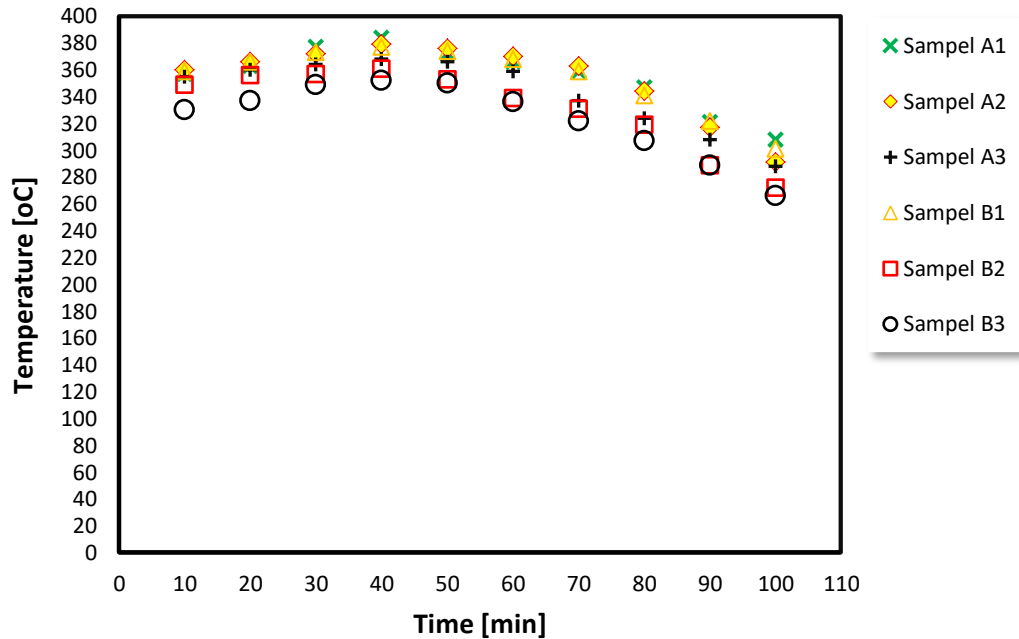


Figure 1. Temperature profile of the briquettes sample

3.3. Briquette mass loss

Figure 2 Displays the loss of mass of the briquette product during the combustion time variety in different compositions of the sample. The results showed that the weight was decreased by 80 % of the total initial mass. As shown in **Fig.2**, as soon as the flame was in contact with the briquette, the combustion time was measured, which detected the mass change at an interval of 10 s.

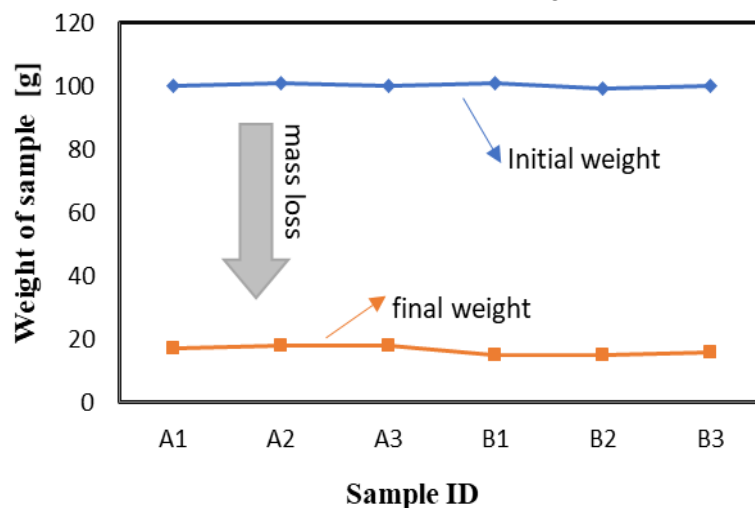


Figure 2. Mass loss of briquette sample

4. Conclusions

The physical properties of the briquette and its agglomerates have been studied using inorganic binders. The different compaction pressure and composition have no significant effect on the briquette formed on all physical properties examined. The calorific value is influenced by the composition and

compaction strain. A higher calorific value of 5700 kal/g was obtained at a lower compaction strain, higher wood biomass and lower bottom ash (70:30-A1). At the starting of the combustion time, the moisture content (MC) passed out of the briquette sample, indicated by mass loss of the briquette materials.

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References

- [1] Mendoza Martinez C L, Alves Rocha E P, Oliveira Carneiro A de C, Borges Gomes F J, Ribas Batalha L A, Vakkilainen E and Cardoso M 2019 Characterization of residual biomasses from the coffee production chain and assessment the potential for energy purposes *Biomass and Bioenergy* **120** 68–76
- [2] Go A W, Conag A T, Igdon R M B, Toledo A S and Malila J S 2019 Potentials of agricultural and agro-industrial crop residues for the displacement of fossil fuels: A Philippine context *Energy Strateg. Rev.* **23** 100–13
- [3] Werther J, Saenger M, Hartge E U, Ogada T and Siagi Z 2000 Combustion of agricultural residues *Prog. Energy Combust. Sci.* **26** 1–27
- [4] Lanzerstorfer C 2019 Combustion of miscanthus: Composition of the ash by particle size *Energies* **12**
- [5] Zeng T, Weller N, Pollex A and Lenz V 2016 Blended biomass pellets as fuel for small scale combustion appliances: Influence on gaseous and total particulate matter emissions and applicability of fuel indices *Fuel* **184** 689–700
- [6] Stolarski M J, Szczukowski S, Tworkowski J, Krzyzaniak M, Gulczyński P and Mleczek M 2013 Comparison of quality and production cost of briquettes made from agricultural and forest origin biomass *Renew. Energy* **57** 20–6
- [7] Roy M M and Corscadden K W 2012 An experimental study of combustion and emissions of biomass briquettes in a domestic wood stove *Appl. Energy* **99** 206–12
- [8] Giungato P, Barbieri P, Cozzutto S and Licen S 2018 Sustainable domestic burning of residual biomasses from the Friuli Venezia Giulia region *J. Clean. Prod.* **172** 3841–50
- [9] Whittaker C and Shield I 2017 Factors affecting wood, energy grass and straw pellet durability – A review *Renew. Sustain. Energy Rev.* **71** 1–11
- [10] Mekonnen M M, Romanelli T L, Ray C, Hoekstra A Y, Liska A J and Neale C M U 2018 Water, Energy, and Carbon Footprints of Bioethanol from the U.S. and Brazil *Environ. Sci. Technol.* **52** 14508–18
- [11] Simangunsong B C H, Sitanggang V J, Manurung E G T, Rahmadi A, Moore G A, Aye L and Tambunan A H 2017 Potential forest biomass resource as feedstock for bioenergy and its economic value in Indonesia *For. Policy Econ.* **81** 10–7
- [12] Nanda S, Mohanty P, Pant K K, Naik S, Kozinski J A and Dalai A K 2013 Characterization of North American Lignocellulosic Biomass and Biochars in Terms of their Candidacy for Alternate Renewable Fuels *Bioenergy Res.* **6** 663–77
- [13] Barzegar R, Yozgatligil A, Olgun H and Atimtay A T 2020 TGA and kinetic study of different torrefaction conditions of wood biomass under air and oxy-fuel combustion atmospheres *J. Energy Inst.* **93** 889–98
- [14] Matakah F, Soroushian P, Ul Abideen S and Peyvandi A 2016 Use of non-wood biomass combustion ash in development of alkali-activated concrete *Constr. Build. Mater.* **121** 491–500
- [15] Chen H, Liu Z, Chen X, Chen Y, Dong Z, Wang X and Yang H 2020 Comparative pyrolysis behaviors of stalk, wood and shell biomass: Correlation of cellulose crystallinity and reaction kinetics *Bioresour. Technol.* **310** 123498
- [16] Xin X, Pang S, de Miguel Mercader F and Torr K M 2019 The effect of biomass pretreatment on catalytic pyrolysis products of pine wood by Py-GC/MS and principal component analysis *J. Anal. Appl. Pyrolysis* **138** 145–53
- [17] Barbuzza E, Buceti G, Pozio A, Santarelli M and Tosti S 2019 Gasification of wood biomass

- with renewable hydrogen for the production of synthetic natural gas *Fuel* **242** 520–31
- [18] Kozlov A, Marchenko O and Solomin S 2019 The modern state of wood biomass gasification technologies and their economic efficiency *Energy Procedia* **158** 1004–8
- [19] Zubairu A and Gana S A 2014 Production and Characterization of Briquette Charcoal by Carbonization of Agro-Waste *Energy and Power* **4** 41–7
- [20] Patil G 2019 the Possibility Study of Briquetting Agricultural Wastes for Alternative Energy *Indones. J. For. Res.* **6** 133–9
- [21] Bajare D, Bumanis G and Upeniece L 2013 Coal combustion bottom ash as microfiller with pozzolanic properties for traditional concrete *Procedia Eng.* **57** 149–58
- [22] Amrullah A, Syarief A and Saifudin M 2020 Combustion Behavior of Fuel Briquettes Made from Ulin Wood and Gelam Wood Residues *Int. J. Eng. Trans. B Appl.* **33** 2365–71