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COMBUSTION BEHAVIOR AND EMISSION OF CARBONIZED BIOMASS-LIGNITE BLENDED BRIQUETTES

Lukas Kano Mangalla, Mustarum Musaruddin, Agustinus Lolok

Engineering Faculty of Halu Oleo University, Indonesia

*Email: lk.mangalla@gmail.com

Abstract

Karakteristik dan Emisi Pembakaran pada Briket Campuran Biomasa-Lignit. The biomass briquette is an alternative energy resources for the home industries as well as the power generations in many countries. In this study, the combustion behavior and emission characteristic of bio-briquettes from carbonized biomass (e.q.; Rice-hull and teak wood) and lignite coal blended are comprehensively investigated. The biomass used in this experiment consists of 50% rice husk and 50% teakwood. Biomass (B) and lignite (C) were mixed together with a composition of 50% C/B, 70% C/B and 100% C/B respectively. All compositions were added with 30% binder from cassava. Each composition was selected 3grams, 4 grams and 5 grams to be briquetted inside a cylindrical molding (17mm diameter) and pressed under 100kg/cm^2. The bio-briquettes are dried naturally at atmospheric temperature for 4 days before examined. The combustion performance and emission characteristics of each type of briquettes were investigated in a cylindrical combustion furnace equipped with measurement devices such as mass balance, thermocouple and exhaust gas analyzer. The burning rate and furnace temperature of each fuel composition were measured during the combustion process. An analysis was performed from the comparison of the data recorded in the form of graphs and tables. Emissions of the bio-briquettes combustion were examined using digital smoke analyzer, MEXA Analyzer, during the combustion process. The results of the study indicate that additional of the biomass carbonized into bio-briquettes offers the advantageous on combustion rate and emissions pollution. The rapid increase in the temperature in the combustion chamber was affected by the reaction rate between a fuel and oxygen as well as the size of fuel burned. The smaller the briquettes result in the faster the burning process and leads the higher the temperature in the combustion chamber.

Keywords: *Biomass-lignite briquette, binder, combustion furnace, temperature, emission*

Abstrak

Briket biomassa merupakan salah satu sumber energi alternative untuk industri rumah tangga dan pembangkit tenaga di beberapa negara. Penelitian ini mempelajari secara luas mengenai karakteristik dan emisi gas hasil pembakaran briket yang terbuat dari arang biomassa dan batubara lignit. Biomassa arang yang digunakan dalam eksperimen ini terdiri dari 50% kulit gabah dan 50% kayu jati. Biomassa (B) dan lignite (C) divariasikan pada komposisi 50% C/B, 70% C/B dan 100% C/B dan dicampurkan dengan 30% perekat dari ubi kayu. Setiap komposisi tersebut diambil 3gram, 4 gram and 5 gram untuk dibriketkan dalam cetakan (17mm diameter) dibawah tekanan 100kg/cm2. Briket yang dihasilkan kemudian dikeringkan secara alami selama 4 hari. Karakteristik pembakaran dan emisi gas dari setiap komposisi briket diuji dalam tungku silinderis yang dilengkapi dengan alat ukur seperti timbangan digital, thermocouple and exhaust gas analyzer. Laju pembakaran dan temperatur hasil pembakaran biobriket diamati selama proses pembakaran berlangsung Demikian pula dengan emisi gas hasil pembakaran, pengukuran dilakukan menggunakan MEXA Analyzer untuk setiap komposisi briket. Hasil penelitian menunjukkan bahwa penambahan karbon biomassa ke dalam briket yang dibuat menunjukkan perbaikan laju pembakaran dan emisi gas buang yang dihasilkan. Laju peningkatan temperatur pada ruang pembakaran dipengaruhi oleh laju pembakaran yang merupakan efek dari ukuran briket dan banyaknya udara pembakaran yang tersedia. Semakin kecil ukuran briket maka laju pembakaran semakin besar dan menyebabkan suhu ruang pembakaran makin tinggi.

Kata Kunci *: Briket biomassa, perekat, tungku pembakaran, suhu, emisi pembakaran*

1. Introduction

Combustion of fossil fuel can increase the amount of emission pollutions in the atmosphere and affects the global warming. According to Sebnem et al, 2013, carbon dioxide (CO_2) increases significantly from 4 million tons/year to 28 million tons/year during the last 60 years. The increase of the emissions pollution and the limited supply of fossil fuel lead the researcher in the automotive industrial to explore more on alternative fuel resources such biomass fuel.

Indonesia as the agricultural country has abundant potential of biomass especially agro residues such as rice husk, rice straw, coconut fiber, coconut shell, palm oil shell, palm oil fiber, bagasse, wood chip and sawdust. The total biomass energy of this country can reach about 434,008.00 GWh (Samsiro et al, 2007). Unfortunately, most of this biomass has low energy density and many problems in handling, storage and transportation. Therefore, densification in the form of briquettes or pellets is the attractive solution for improving energy density, heat capacity and combustion (Saptoadi, 2008). Solid fuel such as charcoal and coal can be added to biomass briquettes to increase the heating value and combustibility as well as to reduce pollution emissions (Grover et al, 1996; Kwong et al, 2004). Mangalla et al, 2010, investigated combustion characteristics of carbonized rice husk and teak wood and reveal that the addition of teak wood char on rice husk briquettes can improve the burning rate and reduce particulate and CO emission of the bio-briquettes. Biomass briquettes can be used as an alternative energy source for domestic heating and power generation system in large industries (Kettunen, 2004).

It is generally expected that bio-briquettes can maintain the high burning rate during combustion process and produce high temperature and low pollution emissions. In this study, the combustion characteristics and emission pollution of biomass and lignite coal briquettes were investigated.

2. Materials and Method

Materials used in this experiment consist of carbonized rice husk and teak wood, lignite and binder. The composition of 50% rice husk and 50% teak wood is defined as biomass. The biomass (B) are then mixed with lignite coal (C) of 50% C/B, 70% C/B and 100% C/B volume, respectively. The properties of materials used in this study can be seen in Table 1. It shows that lignite has higher carbon fixed than other material and it is expected to improve the burning rate of the bio-briquettes. All compositions were added with 30% binder made from cassava. Each composition was selected 3 grams, 4 grams and 5 grams to densify as a briquette inside cylindrical molding (17 mm diameter) and pressed under constant pressure of 100kg/cm^2. Figure 2 shows the example of the briquettes produced in this work. Bio-briquettes are dried naturally at room temperature for 4 days before examining inside the cylindrical combustion furnace. The schematic of experimental apparatus of this study can be seen in Figure 3.

Table 1. Properties of materials

Properties	Rice husk carbonized	Teakwood carbonized	Lignite
Moisture (%)	5,93	10,74	11,98
Fixed Carbon (%)	16,59	12,1	34,75
Volatile matter (%)	61,02	87,9	44,16
Ash (%)	16,46	1,19	20,15

Figure. 1. Cylindrical molding of briquettes

Figure 2. Sample of briquettes

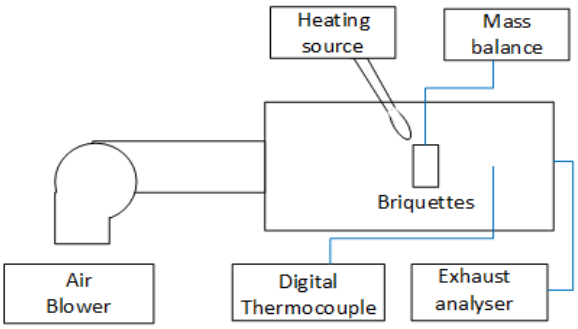

Figure 3. Schematic of experimental apparatus

Combustion performance and emissions characteristics of each type of briquettes were investigated in a cylindrical combustion furnace equipped with measurement devices such as mass balance, thermocouple and exhaust analyzer. Combustion of fuel was supplied with air compressor at a velocity of 0.5 m/sec and the LPG burner was used as a source of heat for briquette. In this experiment 4 pieces of each size briquettes were selected and placed on the perforated plate. The burning rate of each experiment was recorded using digital mass balance at each 15 second. During combustion process, temperature of combustion chamber will increase. The measurement of combustion temperature was placed at around 2 cm behind the briquettes burning. Analysis was performed from the comparison of the data recorded in form of graphs and tables. Emissions of the bio-briquettes combustion were examined using digital smoke analyzer and MEXA Analyzer, during combustion process.

3. Results and Analysis

The combustion performances of fuel briquettes can be seen in Figure 4-6. The burning rate of each briquettes was examined by measured the loss of weight of the fuel during combustion. It seems that high carbon fixed in lignite coal affects significant on the duration and burning rate of the briquette. It is found that the higher the lignite the higher the burning rate. This phenomenon makes shorter the combustion periods and leads to produce lower temperature in combustion chamber. On the other hand, burning rate of biomass is lower at the beginning of combustion but longer the period of burning and the temperature become higher. Moisture content in biomass is also influence the burning rate and temperature of combustion process. It is need longer enough time to evaporate out of the moisture that make the longer time of burning. Combustion rate of the briquettes can reach the maximum of 30.33 mg/sec for the briquette mass of 3 grams, whereas briquettes of 4 grams and 5 grams can reach maximum of 31.00 mg/sec and 30.33 mg/sec respectively.

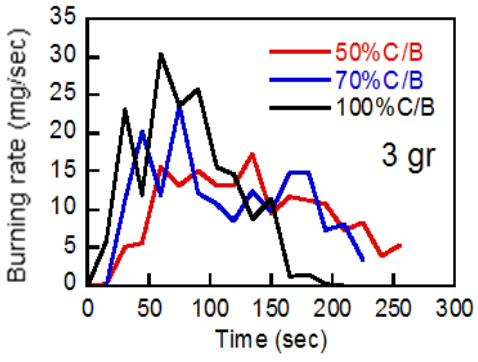

Figure 4. Burning rate of briquettes 3 grams

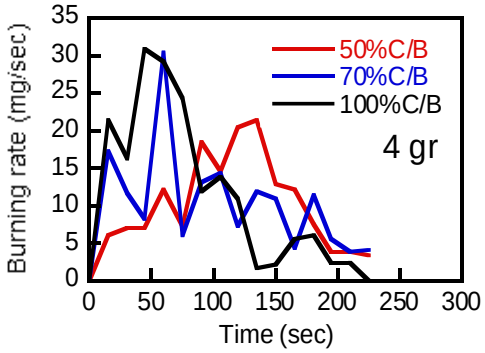

Figure 5. Burning rate of briquettes 4 grams

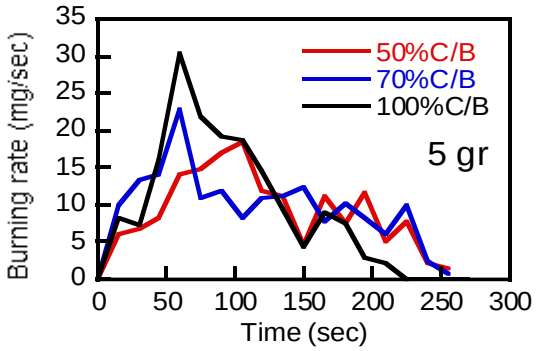

Figure 6. Burning rate of briquettes 5 grams

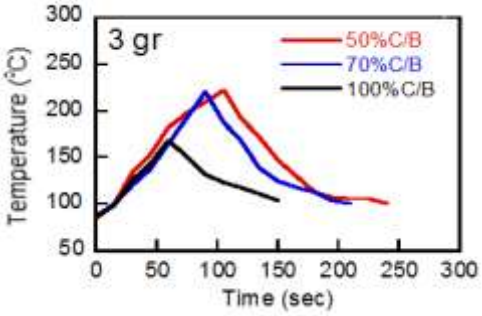

Figure 7. Temperature of briquettes 3 gram

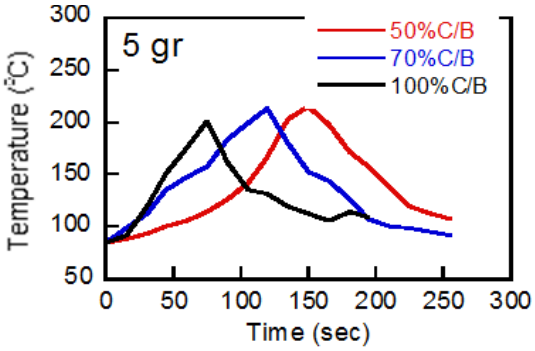

Figure 8. Temperature of briquettes 4gram

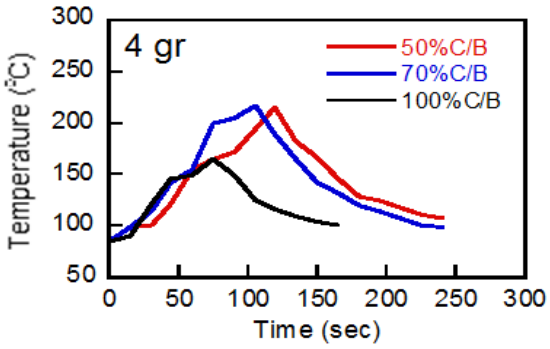

Figure 9. Temperature of briquettes 5gram

Temperature of combustion chamber is mainly affected by the reaction rate happened between fuel and oxidizer inside combustion chamber. Complete combustion of the fuel depends on the availability of oxygen and surface contact between the fuel and oxidizer. Reaction rate can also be influenced by volatile matter in the solid fuel (Mangalla, et al., 2010). Volatile matter in the fuel affects the stability of the reaction rate and tends to increase the temperature in the combustion chamber. Maximum temperature of briquette 3 grams can reach about 222^{o}C, whereas for briquette 4 grams and 5 grams can attain peak of 215^{o}C and 214^{o}C, respectively.

Table 2. Exhaust emissions of the briquettes

Mass	5 gr			4 gr			3 gr		
Emissions	HC %	CO%	CO2%	HC %	CO%	CO2%	HC %	CO%	CO2%
100% C/B	0	0.044	0.36	0	0.045	0.36	0	0.04	0.35
70% C/B	0	0.032	0.35	0	0.032	0.033	0	0.030	0.32
50% C/B	0	0.03	0.3	0	0.032	0.34	0	0.03	0.31

The exhaust emissions of CO and CO_2 were recorded at the peak temperature combustion of each fuel briquettes. Table 2 provides the pollution emissions produced during combustion of the solid fuel. It seems that the higher the biomass content in the briquettes the lower the exhaust emissions. Higher volatile matter in biomass is expected to improve combustion process and reduced pollution emissions of the briquettes. It is interesting to note that the small size and shape of the solid fuel influence also the burning rate and exhaust emissions during combustion. The heat flux can easily penetrate inside the small and thin layer of briquettes and leads the moisture content can easily escape during heating and devolatilization process to make the fuel burned effectively. The minimum emission of CO and CO_2 can be found in 50% C/B for all sizes of briquettes.

4. Conclusion

Based on the previous analysis, it can be concluded that carbonizing biomass and size of the briquettes are important for combustion performances and emissions characteristic. The combustion rate of the briquettes can be affected by the composition and size of briquette materials as well as oxygen supply. Briquettes should be as small as possible and the addition of carbonized biomass in the briquettes must be essential in order to improve the burning rate and emissions pollution.

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