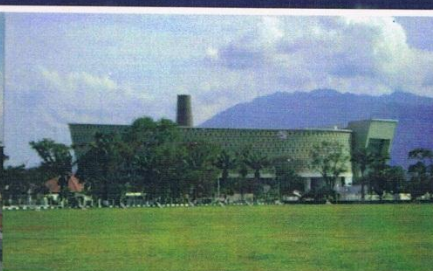


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Fundamental Study on Desulfurization Characteristics of Bio-briquette at Low Temperature Using Calcium Based Adsorbent

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Abstract

Fundamental study on desulfurization characteristics of bio-briquette at low temperature using calcium based adsorbent was studied by using an electric furnace laboratory scale. In the experiments, the coal and palm shell material was selected to produce a bio-briquette which is dolomite or egg shell was added as adsorbent as well. In this study, the air was used as oxidizer, while the temperature in electric furnace was varied from 150 to 400°C, respectively. The experimental results show that the combustion temperature may affect to bio-briquette mass decreasing fraction. In addition, the higher percentage of biomass in bio-briquette shows the higher rate of mass decreasing fraction as well. It is also shown that the SO_x emitted from burning of bio-briquette with dolomite additive is lower than compared to with egg shell additive.

Key words: coal, palm shell, bio-briquette, desulfurizer, low temperature

Introduction

It is recognized that combustion of fossil fuels currently dominates world energy production, and will continue to dominate in the near future. Among fossil fuels coal has the highest potential since not only low cost but also broad availability. Hence, coal can be expected to remain in essential supply well into twenty-first century [1]. Although a part of coals is used for power generation in large scale utility boilers and gasifiers, the amount of coals utilized as a fuel in both middle and small scale industrial boilers and domestic stoves is still large in the developing countries.

The direct combustion of coals, especially low rank coals with high ash, high sulphur and high nitrogen content in industrial boiler and domestic stoves causes more serious pollution. On the other hand, a large amount of biomass (agriculture and forestry wastes) is also being discarded in these countries, such as Indonesia Malaysia and Thailand. In the near future, South East Asia will become one of the largest Crude Palm Oil (CPO) producers in the world. In case of Indonesia, there are many units of palm oil mills, which are almost located in Sumatra and Kalimantan. The capacity is ranged from 20 to 90 t/h of fresh fruit bunches (FFB). However, about 4.6 million t/y of wastes, which consist of empty fruit bunches (EFB), fronds, shell and fibres are formed as by products [2].

From the above aspect, it is necessary to consider of both fuels in order to meet the requirement of both energy supply and pollution control. In order to enhance effective utilization of low rank coals, a new artificial solid fuel called bio-briquette was developed in this study. Low rank coals and forestry wastes (palm shell) were used as biomass to make bio-briquettes. Taking into account the availability these resources, it will be produced a solid mixed fuel composed of coal, and biomass known as *Volumetric Energy Density* (VED).

During to pass two decades, there are a number of studies relating to bio-briquette combustion, such as fundamental study on combustion characteristics of bio-briquette was reported [3], the effect of biomass addition on combustion characteristics of bio-briquette [4], study on

combustion and pollutant control of bio-briquette [5], characteristics of volatile content release during bio-briquette pyrolysis [6], to improve the quality of bio-briquettes for domestic stove used [7] and to reduce SO₂ releases by adding lime-based adsorbent (CaO) into bio-briquettes [8]. From the previous studies still not enough information on desulfurization characteristics of bio-briquette using calcium based adsorbent, especially at low temperature combustion.

Objective of the research is to observe desulfurization characteristics of bio-briquettes by using dolomite and eggs shell at low temperature combustion. Additionally, it is also examined desulfurization characteristics as a function of biomass content.

Experimental Method

Bio-briquette production process

The sample of bio-briquette consists of coal and biomass. The coal test is selected as a low rank coal and it came from Meurebo (West Aceh, Indonesia). The biomass test is selected from palm shell. They came from Aceh Tamiang (East Aceh, Indonesia). The properties of used coal and biomass are shown in Table 1.

Table 1. Properties of coal and biomass tested

Samples	Proximate Analysis [mass %, wet basis]				Sulphur [mass%]	Calorific value [kcal/kg]
	Moisture	VM	FC	Ash		
Coal	5.83	46	42.77	5.40	0.38	5904
Palm shell	4.30	73.65	19.42	2.63	0.11	4865

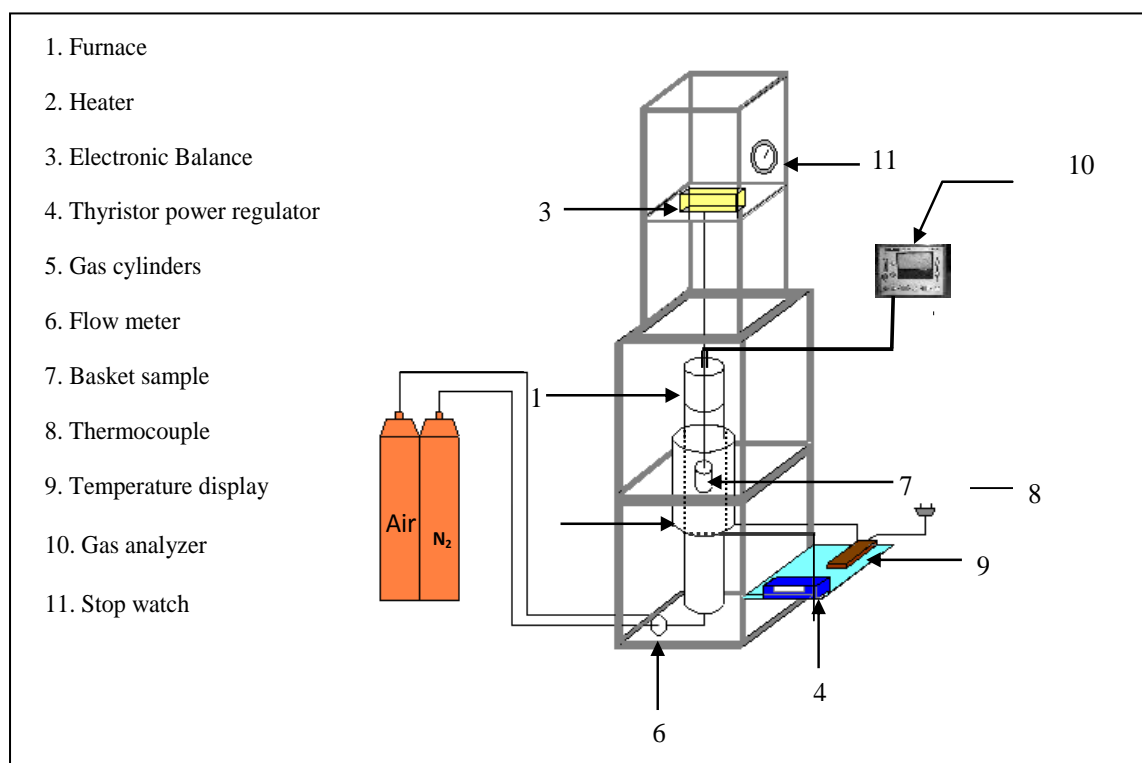


Figure 1. Set up the experimental apparatus.

The coal and biomass were dried and crushed to the mesh size 50/60 separately by electrical sieve before mixing together. The composition of biomass content in a bio-briquette was varied 40, 60 and 100 in mass percentage. The mixer of coal and biomass was input in a die and compressed under the pressure of about 220 MPa by pressing machine, respectively. The diameter of bio-briquette was selected 20 mm. The mass of die charge was selected about 10 gram, respectively.

The experiments were performed in a laboratory scale electrically heated furnace. The combustion temperature was varied in range from 150 °C to 400 °C in air ambient. The schematic diagram of experimental apparatus is shown in Figure 1. It consists of an electrically heated batch furnace, temperature controller and a digital balance.

As shown in Figure 1, the tested bio-briquette was suspended in basket by a wire linked to digital balance and was positioned in the centre of the furnace. The air was fed into the furnace through a flow meter of about 11 litre/min., respectively. The furnace was heated to a predetermined temperature to heat the sample. The sample mass loss was continuously measured by the digital balance. In this experiment assume that the influence of buoyancy on measured mass was small and neglected, respectively.

Results and Discussion

Mass decreasing fraction of bio-briquette

During the combustion process, mass of sample reduces continuously over the time. This phenomenon occurs because of loss the substances contained in bio-briquette. The experimental result of mass decreasing fraction at air heated under temperature is about 150 °C shown in Figure 2. From the figure, the ratio of sample mass reduction is calculated by neglecting the ash produced from combustion. The ratio can be calculated as

$$CWR = (M_0 - M_t)/M_0 \times 100\% \quad (1)$$

Where CWR is ratio of mass reduction, M_0 and M_t are initial and final mass of bio-briquette, respectively. Thus, the unburned mass fraction is determined by using equation:

$$\text{Unburned mass fraction} = 100\% - CWR \quad (2)$$

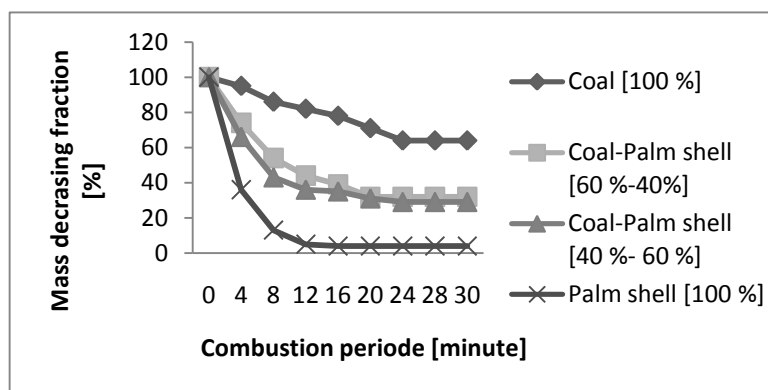


Figure 2. Profile of bio-briquette mass decreasing fraction.

From the experimental results show that biomass content plays an important role on sample mass reduction. The higher biomass content is given, the higher mass reduction is obtained. The mass reduction of briquette composed of 100% palm shell is faster compared to that composed of 100% coal. Furthermore, mass reduction of bio-briquette composed 40% coal + 60% palm shell is faster compared to that with 60% coal + 40% palm shell. This phenomenon occurs because biomass has higher volatile matter rather than coal as confirmed in Table 1. The graph also shows that at beginning of combustion process, the mass reduces significantly. The reason for this significant reduce is because the outer of sample contains volatile matter. At the middle of process, mass reduces gradually because the sample has high fixed carbon content.

Desulfurization characteristics

Combustion of each bio-briquette contributed to different SO₂ concentrations in the flue gas. Sulphur was oxidized during combustion of coal and biomass to produce SO₂ gas. The profile of gas release during coal and palm shell combustion is shown in Fig. 3. From the figure shows that SO₂ release from coal combustion is higher than that palm shell combustion. This is evident since coal has high sulphur content as confirmed in Table 1.

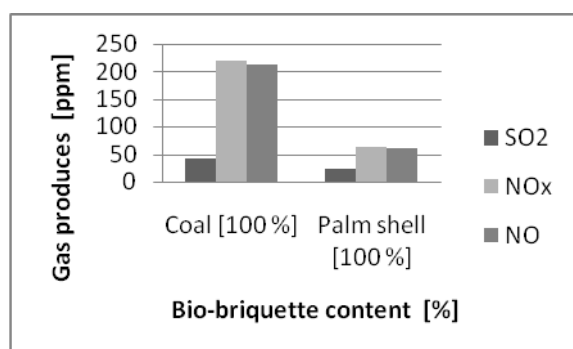
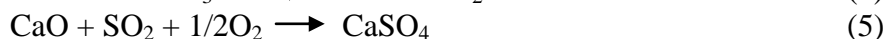


Figure 3. Profile of gas released at combustion temperature was about 400°C

In order to elucidate desulfurization characteristics of bio-briquette combustion, it is the dolomite and egg shell was used in this experiment. The properties of dolomite consist of CaCO₃ and MgO each 62.07 % and 4.14 % mass. For the egg shell has CaCO₃ and MgO each 46.07 % and 2.11 % mass. It is expected that the calcium from adsorbent was calcinated and then captured SO₂ gas with the following reactions.



Profile of SO₂ releases for various absorbent of bio-briquette under combustion temperature about 400°C is shown in Figure 4. From figure shows that the utilization of desulfurizer (dolomite and egg shell) into bio-briquette was decreases the number of SO₂ produced. The briquette composed of 70% coal and 30% dolomite release 5 ppm of SO₂. While for that composed of 70% palm shell and 30% dolomite releases 3 ppm of SO₂. The highest SO₂ is produced by briquette composed 70% coal and 30% egg shell. It is 28 ppm. The sample composed 70% palm shell 30% egg shell produces 4 ppm. This phenomenon occurs because of higher calcium of dolomite.

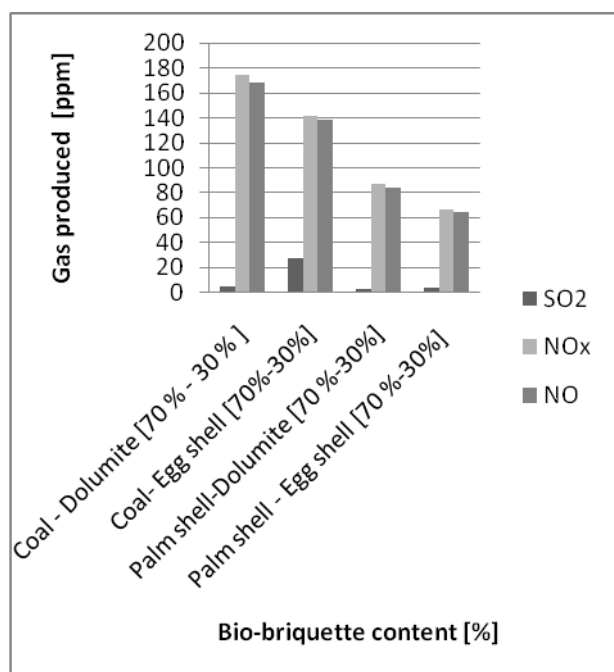


Figure 4. Profile of SO₂ releases from bio-briquette combustion under temperature 400 °C.

Conclusions

Based on the study results, it can be concluded that

1. Mass decreasing fraction of bio-briquette is affected by biomass content.
2. SO₂ produced from burning of briquette composed of 100% coal is higher compared to that 100% palm shell.
3. SO₂ produced from burning of briquette composed of 30% dolomite is lower compared to that coal 30% egg shell.
4. Briquette composed of 70% palm shell and 30% dolomite produces less SO₂ compared to that 70% palm shell and 30% egg shell.

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