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Study of Bio-Coal Briquette as Solid Fuel for Aluminum Smelter

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Abstract

Research on alternative energy today based on issues of global warming and greenhouse effects. The use of coal briquettes from low-calorie coal derived from mines in the province of South Sumatera originally destined for the food industry is less desirable because it emits black and smelly smoke, is difficult to turn on, and it is difficult to shut down quickly. So the thought arises to use this coal briquettes for the manufacturing industry and metal casting. In a previous study, the manufacture of mixed briquettes between low calorie coal (lignite) and biomass was more environmentally friendly due to low sulfur content. Therefore, in this study, a study was conducted to find the best biomass species to be mixed with lignite to bio-coal with the highest carbon content criteria and lowest sulfur content. The results showed that the mixture type between coconut shell and lignite reached the optimum condition with carbon content of 57.923% and the lowest sulfur was 0.259% in the mixture ratio of 9 : 1. The combustion temperature reaches 1500 K at furnace efficiency of 48%.

Keywords: bio-coal briquettes; lignite. coconut shell; enthalpy difference; carbon and sulfur content; flame temperature;

Abstrak (Indonesian)

Penelitian tentang energi alternatif saat ini berdasarkan issue tentang pemanasan global dan dampak rumah kaca. Penggunaan briket batubara dari batubara kalori rendah yang berasal dari tambang di provinsi Sumatera Selatan yang semula diperuntukkan untuk industri makanan kurang diminati karena mengeluarkan asap hitam dan berbau, sulit dihidupkan, dan sulit dimatikan dengan cepat. Sehingga timbul pemikiran untuk menggunakan briket batubara ini untuk industri manufaktur dan pengecoran logam. Pada penelitian sebelumnya, pembuatan briket campuran antara batubara kalori rendah (lignite) dengan biomassa ternyata lebih ramah lingkungan karena kadar sulphur yang rendah. Oleh karena itu pada penelitian ini dilakukan kajian untuk mencari jenis biomassa yang paling cocok untuk dicampur dengan lignite menjadi bio-coal dengan kriteria kandungan karbon tertinggi dan kandungan sulphur terendah. Hasil penelitian ternyata jenis campuran antara tempurung kelapa dan lignite mencapai kondisi optimum dengan kandungan karbon 57,923 % dan sulphur terendah yaitu 0,259 % pada perbandingan campuran 9:1. Temperatur pembakaran mencapai 1500 K pada effisiensi tungku 48%.

Katakunci: bio-coal briket; lignite; tempurung kelapa; perbedaan enthalpi kandungan karbon dan sulfur; temperatur nyala api;

1. Introduction

Nowadays, the energy source used in the metal casting industry comes from oil, diesel oil, kerosene, used oil, and other fossil fuels. Given the warming and global warming, in this study conducted a study of several types of biomass which will be made into bio-coal briquettes. The selection is based on carbon (C) and Sulfur (S) contents by each type of biomass, i.e., palm leaves, coconut shell, palm shell, palm stem, pine leaves, and rice husk.

South Sumatera is rich in coal, especially low-calorie coal sold in the domestic market. This coal is lignite type which is used to make coal briquettes. In the beginning, the briquette factory built by the government was for fuel in the food industry. But the combustion of briquettes is difficult to ignite and be extinguished, in addition, it produces a lot of smokes, therefore it is not interesting to the consumers and less market interest. At first, the use coal briquettes as solid fuel for manufacturing and metal casting industries was desirable, but the maximum flame temperature of 850 C only was not enough to melt the metals. The research [1] that has been done by changing the design of the furnace, the combustion temperature of coal briquettes can reach 1350 C and can be used for casting of metals whose melting temperature is about 1000 such as copper, gold, silver, and brass. Some researches dealing with the issue of global warming and air pollution have shown that coal mixed with biomass will be a more environmentally friendly fuel due mainly to low sulfur content.

In this research, an analytical study was conducted to select the right type of biomass to be mixed with lignite into bio-coal briquettes.The biomass will be blended with lignite at a ratio of 1: 1 for a total weight of 10 kg bio-coal. Furthermore, an analytical study was conducted to calculate the ratio that would produce the highest carbon and the lowest sulfur contents.

1.1. Flame Temperature

In the metal casting industry, one of the most widely casted metals is aluminum. The Aluminum melting point is 659 ℃ or 932 K. However, the liquid Aluminum will be poured into the mold at a temperature of 750 ℃ or 1023 K. The most widely used melting furnace is crucible. At a melt capacity below 150 kg, the efficiency of the crucible furnace is low and its height varies depending on its chemical composition [1]. Figure 1 shows that the higher the flame temperatures in the combustion chamber the higher the furnace ef-

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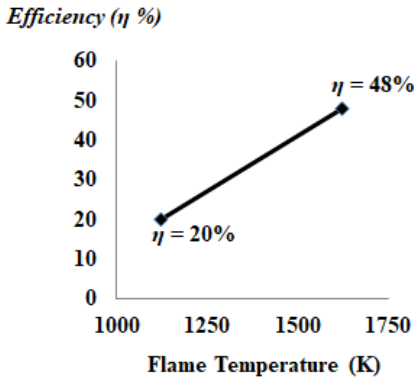

Figure 1. Relationship between flame temperature (K) and furnace efficiency (η %) [1]

ficiency.

The temperature of the flame is dependent on the fuel type and the fuel content of C, H, O, S, and N. While the efficiency of the furnace depends on the design of the furnace and the furnace material. The type of selected material will determine the losses that will occur during the combustion process. Elements C, H, S will react with oxygen in the air during the combustion process and will release the heat as a result of the EXOTHERMIC REACTION taking place. Nitrogen partially reacts with oxygen which then generates NOx as exhaust emissions and partially unreacted but will absorb the heat from the combustion reaction results as an endothermic reaction. The chemical reactions occurring in the adiabatic combustion reaction [2] are:

$S + O_2 \rightarrow SO_2$	ΔH =	-70,947	kcal/kg (exothermic reaction)
$N_2 \rightarrow N_2$	ΔH =	0	kcal/kg
$C + O_2 \rightarrow CO_2$	ΔH =	-94,054	kcal/kg (exothermic reaction)
$H_2 + ½ O_2 \rightarrow H_2O$	ΔH =	-57,796	kcal/kg (exothermic reaction)
$O_2 \rightarrow O_2$	ΔH =	0	kcal/kg

The amount of chemical content above in the fuel will result in greater enthalpy differences. The higher the combustion temperature the larger the resulting enthalpy. The relationship between

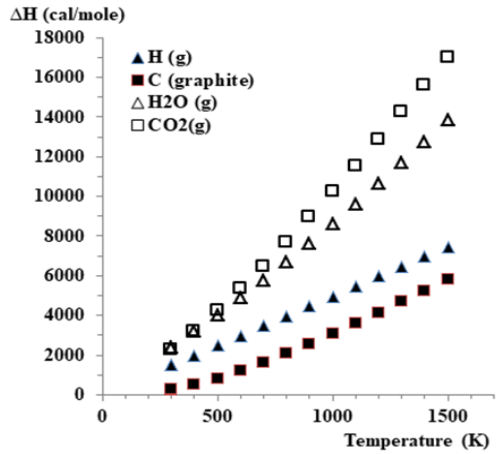

Figure 2. The relationship between the combustion reaction temperature (K) and enthalpy (cal/mol)

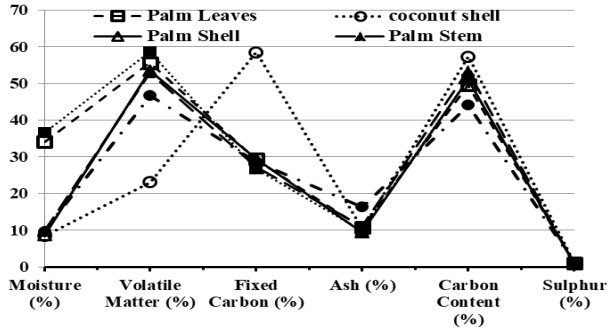

Figure 3. Graph of bio-coal chemical composition based on biomass type

combustion temperature or temperature on the flame and the enthalpy is shown in Figure 2.

Generally, the enthalpy of the element will increase after the combustion chemical reaction. The total

enthalpy of all combustion reactions is the calorific value of the fuel.

1.2 Types of Biomass and Chemical Content

The types of biomass for bio-coal are oil palm leaves, coconut shell, palm shell, palm frond, pine leaf, and rice husk, studied by comparing its composition based on the results of ultimate and proximate analysis shown in Table 1.

Table 1 shows that the most sulfur-containing biomass is palm leaves and the least is the palm stem. While the highest carbon content in coconut shell while the lowest is rice husk. The content of lignite coal is shown in Table 2 below.

The study on the composition of bio-coal mixture was done by calculating the enthalpy of the reaction result between each type of biomass with lignite in the mixture of 1 : 1 for the weight of bio-coal 10 kg.

2. Data analysis and discussion

The results of the calculations for each of the biomass and lignite coal mixtures shown in the graph of Figure 3, showing that the mixture of coconut shell biomass with lignite contains the highest carbon and the lowest sulfur.

The mixture of coconut shell and lignite in the ratio of 1: 1 to 10 kg mixture, it appears that the mix between coconut shell and lignite will yield the highest heat value, that is 5843.5 kcal / kg and

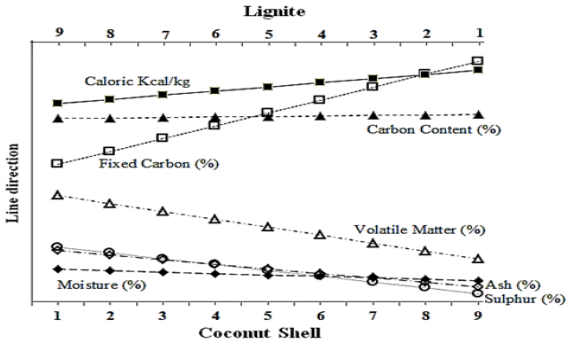

Figure 4. Line direction based on the composition of coconut shell to lignite in wt %

Table 1. Chemical content of several types of biomass

Matter	Moisture (%)	Volatile Matter (%)	Fixed Carbon (%)	Ash (%)	Carbon Content (%)	Sulphur (%)
Palm leaves [2]	57.6	75.9	20.1	4	42.5	0.169
Coconut shell [3]	6.17	10.85	78.32	3.22	58.07	0.08
Palm shell [4]	6.76	71.54	20.28	1.42	45.61	0.09
Palm stem [5]	8.95	70.33	15.96	4.76	50.23	0.003
Pine leaves [2]	62.5	81.9	14.9	2.5	45.5	0.095
Rice husk [6]	8.84	57.95	18.64	15.24	31.65	0.11

Table 2. Chemical content of lignite

Matter	Moisture (%)	Volatile Matter (%)	Fixed Carbon (%)	Ash (%)	Carbon Content (%)	Sulphur (%)	HHV (kcal/kg)
Lignite [1]	10.57	35.36	38.55	17.34	56.6	1.87	6007

the lowest sulfur content, that is: 0.975%.

An optimum weight ratio of coconut shell and lignite was determined where compromise between the lowest sulfur, fixed carbon composition and the highest heating value. Calculations were performed for various comparison of coconut shell to lignite weight%. The result of the calculation is depicted on the graph in Figure 4 below.

Based on the graph in Figure 4 above, the enthalpy is achieved at 6000-8000 kcal/kg ie 7185 kcal/kg with combustion or flame reaching temperature of 1500 K. While on aluminum casting, 1023 K is required. Therefore in this research found that bio-coal with a ratio of 9 parts coconut shell and 1 part lignite is the optimum mixture.

3. Conclusion

Bio-coal which has the highest carbon content value and the lowest sulfur is mixture of coconut shell with lignite at 9:1 ratio with flame temperature reaching 1500 K.

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