Bio-coal briquettes using low-grade coal

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Abstract.
The technology in using briquettes for fuel has been widely used in many countries for both domestic and industrial purposes. Common types of briquette used are coal, peat, charcoal, and biomass. Several researches have been carried out in regards to the production and the use of briquettes. Recently, researches show that mixing coal and biomass will result in an environmentally friendly briquette with better combustion and physical characteristics. This type of briquette is known as bio-coal briquettes. Bio-coal briquettes are made from agriculture waste and coal, which are readily available, cheap and affordable. Researchers make these bio-coal briquettes with different aims and objectives, depending on the issues to address, e.g. utilizing agricultural waste as an alternative energy to replace fossil fuels that are depleting its reserves, adding coal to biomass in order to add calorific value to bio-coal briquette, and adding biomass to coal to improve its chemical and physical properties. In our research, bio-coal briquettes are made to utilize low grade coal. The biomass we use, however, is different from the ones used in past researches because it has undergone fermentation. The benefits of using such biomass are 1. Fermentation turns the hemi cellulose into a simpler form, so that the burning activation energy decreases while the calorific value increases. 2. Enzym produced will bind to heavy metals from coal as co-factors, forming metals that are environmentally friendly.

1. Introduction

The development of industrial centers requires the use of fuel. Unfortunately, the scarcity of kerosene and the high price of LPG as kerosene conversion has triggered the emergence of the need for alternative energy sources. This is stated in the Presidential Regulation of the Republic of Indonesia number 5 of 2006 on National Energy Policy, which states that the government invites all parties and the people of Indonesia to support the development of alternative energy source substitute fossil fuel.

The existence of renewable energy sources is needed for the provision of sustainable energy sources. The use of briquettes for fuel has been a technology widely used by many countries, especially in developing countries.

Several researches have been carried out in regards to the production and the use of briquettes for both domestic and industrial purposes. Common types of briquettes used are coal, peat, charcoal, and biomass briquettes [1]. Recently, researches show that mixing coal and biomass will result in an environmentally friendly briquette with better combustion and physical characteristics. [2]. Coal and biomass are solid fuels that have different characteristics. Coal has high carbon content and calorific value, moderate ash content and low volatile content, while biomass has high volatile content but low carbon content [3]. This type of briquette is known as bio-coal briquettes. They are made from agriculture waste and coal which are readily available, cheap and affordable and made with a variety of purposes depending on the issues to address e.g. utilizing agricultural waste as an alternative energy to replace fossil fuels that are depleting its reserves, adding coal to biomass in order to add calorific value to bio-coal briquette, and adding biomass to coal to improve its chemical and physical properties.

In our research, bio-coal briquettes are made to utilize low grade coal with biomass additives (wastes) that have been fermented to improve the chemical and physical properties [4].

The purpose of this article is to introduce bio-coal briquettes that have been made by several researchers along with its significance.

2. Discussions

The making of bio- coal briquettes that utilizes agricultural waste as an alternative energy to replace fossil fuels that are increasingly depleted its reserves is the topic of this section. Concerns about the depletion and the high cost of fuel oil (BBM), increasingly felt in recent years, is the reason behind the idea of processing biomass into alternative fuel [5].

The research discussed in this section uses coconut fiber biomass mixed with lignite coal, a mixture of coconut husk and lignite coals (70% : 30%) with binder variations using starch and molasses 1 gram, 2 gram and 3 gram. The main aspect being observed is combustion characteristics. The bio coal briquettes studied receives the same treatment, i.e. 100 kg/cm^2 pressing, 4 grams in weight, air velocity of 0.3 m/sec during combustion with the temperature between 100^o C-120^o C, pre-heated temperature of 52^o C - 56^o C and air temperature of 34^o C - 38^o C.

Table 1. Characterization of Coal and Coconut Fiber.

No.	Parameter	Lignite Coal	Coconut Fiber
1.	Moisture content (%)	14.31	2.45
2.	Volatile matter (%)	2.02	1.34
3.	Ash content (%)	69.53	21.62
4.	Fixed carbon (%)	5289.395	3942.751
5.	Calorific value (MJ/kg)	14.14	74.59

Table 2. The Result of Pollutant Analysis from Burning Bio-Coal Briquette.

No.	Binder Composition	Pollutant		
		HC (ppm)	CO (%)	NO_x (%)
1.	Starch 1 gram	10	0.0046	0.00035
2.	Starch 2 gram	10	0.0044	0.00034
3.	Starch 3 gram	10	0.0045	0.00032
4.	Molasses 1 gram	10	0.0034	0.00030
5.	Molasses 2 gram	70	0.0038	0.00034
6.	Molasses 3 gram	120	0.0043	0.00036

The result is that bio-coal briquettes given starch binders have higher combustion temperatures and lower pollution when compared to bio-coal briquettes given molasses binder.

Biomass, particularly agricultural residues, seems to be one of the most promising energy resources for developing countries. The idea of utilizing the residues from agricultural sectors as primary or secondary energy resources is considerably attractive. This kind of waste is available as free, indigenous and environmentally friendly energy sources [6]. The density equation of bio-coal briquettes is also observed in the experiment.

Maize cob was utilized as the major ingredient for producing bio-coal briquettes. The maize cob is treated with sodium hydroxide solution before being mixed with coal fine. The ratios of coal:maize is 1:2 and 1:3 respectively. The range of briquetting pressure is between 4-8 Mpa. The result is that the density of bio-coal briquettes ranges between 0.98 to 1.12 g/cm^3 and that the density is strongly affected by both parameters.

Finally, the relationship between biomass ratio, briquetting pressures and briquetting density is developed and validated using regression technique.

Another material used for briquette is rice straws. These are cheap materials and are easy to find in Indonesia. Rice straw briquettes, however, have a low calorific value, so to increase the calor, a mixture of another material is required. The material used is coal as it has a high calorific value [7].

This research observes the influence of composition and particle size to combustion characteristics. The research method is done by experimental test and computer simulation with variations of material composition and particle size.

Table 3. The results of briquette proksimat analysis.

No.	Briquette sample C/B	Partcle size Mesh	Moisture (%)	Ash (%)	Volatil Matter (%)	Calorific value (cal/g)	Fixed Carbon (%)	Density g/cm ^{3}
1	SNI	-	≤ 8 %	≤ 8 %	≤ 15 %	≥ 5000	--	-
2	100/0	35	3.812	14.759	10.378	5645.111	71.040	0.855
3	70/30	35	4.437	21.250	11.547	5275.926	62.768	0.823
4	50/50	35	5.176	26.231	12.484	5037.127	56.105	0.743
5	30/70	35	6.000	33.761	13.439	4832.016	46.793	0.697
6	0/100	35	7.177	41.627	14.448	4463.499	36.746	0.629
7	100/0	50	4.470	14.302	9.8675	5867.457	71.347	0.888
8	70/30	50	5.198	20.429	11.155	5460.195	63.216	0.842
9	50/50	50	6.072	25.219	11.965	5185.627	56.747	0.762
10	30/70	50	7.197	33.228	12.592	4976.793	46.983	0.730
11	0/100	50	7.886	41.203	13.980	4609.149	36.931	0.707

C = Coal, B = Biomass

From Table 3, it can be seen that the composition of the mixture and particle size influences to the content of briquette components. The combustion rate of the computer simulation results using fluent v 3.6.2 software, known in briquettes with 50% coal and 50% straw at 35 mesh there is a temperature distribution of about 743 ^{o}K or 469^{o}C, this is in accordance with the SNI 01-6235-2000, the requirement in the event of complete flame burning, fire must reach 300^o C-500^o C.

Recently, researches show that mixing coal and biomass will result in an environmentally friendly briquette with better combustion and physical characteristics. In this experiment, briquettes of coal and corn cob were produced. The different briquette samples produced are made by blending various compositions of coal and corn cob in the following ratios of 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 using bitumen as a binder and calcium hidroxide as the desulphurizing agent. The briquettes are produced mechanically using a manual briquetting machine with pressure maintained at 5 Mpa.

Table 4. The Results of proximate analysis of the various briquette samples.

No	Briquette sample CD:CCB (%)	Moisture content (%)	Density (g/cm^3)	Sulphur content (%)	Volatile matter (%)	Ash content (%)	Fixed carbon (%)	Porosity index (%)	Calorific values (KJ/kg)
1	100:0	2.15	0.714	8.22	11.76	21.05	65.04	22.02	158.88
2	80:20	1.20	0.453	8.79	26.48	37.69	50.69	39.68	148.36
3	60:40	1.50	0.414	7.56	32.50	32.30	44.83	48.12	124.45
4	40:60	2.50	0.242	6.39	36.12	27.45	40.40	53.66	114.56
5	20:80	3.38	0.222	5.89	41.41	23.00	34.09	69.87	98.96
6	0:100	4.06	0.154	3.01	45.77	18.88	30.71	78.69	82.48

CD:Coal dust, CCB:Corn cob

The results of the proximate analysis show that the different compositions of the briquettes has reasonable calorific value but that 60% coal: 40% corn cob briquettes with following values for ash content 20.17 %, fixed carbon 44.83%, moisture content 2.50%, density 0.414 g/cm3, volatil matter 32.50%, porosity index 48.12%, caloric value 124.45 KJ/kg, water boiling test 2.10 mins, ignition time

29.56 secs, burning time 19.76 mins and sulphur content 7.56% exhibited optimum combustible quality when compared with other compositions of briquettes produced.

Table 5. The Result of Burning Rate, Burning Time and Ignition.

No.	Briquette sample CD:CCB (%)	Water boiling test (min)	Burning time (min)	Ignition time (secs)
1	100:0	1.63	24.89	37.00
2	80:20	1.64	23.28	56.14
3	60:40	2.10	19.76	48.56
4	40:60	2.62	18.56	43.10
5	20:80	3.14	16.43	33.50
6	0:100	4.57	14.13	27.20

This work studies the effect of maize cob biomass on the properties of coal briquettes [1]. Proximate analysis of the maize cob and coal are determined. Varying samples of briquettes are produced by blending different loads of maize cob with coal in the ratio of 0:100, 10:90, 15:85, 20:80, 25 : 75 and 30:70 using casava starch as binder, and calcium hydroxide as the desulphurising agent. Calorific value, porosity index, compessive strength, and bulk density of the briquettes are analysed, and compared with the control (coal briquette).

Table 6. Characterization of Coal and Maize Cob.

No.	Parameter	Coal	Maize
1	Moisture content (%)	6.10	12.20
2	Volatile matter (%)	23.00	54.60
3	Ash content (%)	14.00	3.30
4	Fixed carbon (%)	56.90	29.90
5	Calorific value (MJ/kg)	24.29	14.50

Table 7. Calorific Value of The Briqutte.

No.	Biomass load	Calorific value (MJ/kg)
1	0% maize cob	26.8
2	10% maize cob	25.9
3	15% maize cob	25.1
4	20% maize cob	24.4
5	25% maize cob	23.9
6.	30% maize cob	23.2

Table 8. Effect of Maize Cob Biomass on the Porosity index, Bulk density and compressive strength of the briquette samples.

No.	Biomass load	Porosity index	Bulk density (kg/m^3)	Compressive Strength (N/mm^2)
1	0% maize cob	0.21	10.0×10^2	1.31
2	10% maize cob	0.26	9.4×10^2	0.97
3	15% maize cob	0.28	9.2×10^2	0.95
4	20% maize cob	0.31	9.0×10^2	0.87
5	25% maize cob	0.34	8.8×10^2	0.81
6.	30% maize cob	0.37	8.6×10^2	0.63

The results of the analysis shows higher porosity index values, 0.26-0.37, for the bio coal briquettes than for the coal briquette,0.21, and lower calorific value, 23.2-25.9 MJ/kg, compressive strength, 0.63-0.97 N/mm^2 , bulk density, 8.6 x 102-9.4 x 102 kg/m^3, than that of the coal briquette 26.8 MJ/kg, 1.31 N/mm^2 and 10.0 x 102 kg/m^3 respectively. Also, the calorific value, compressive strength, and bulk density of the bio-coal briquettes decreases as the percentage of biomass load increases from 10% to 30%, while the porosity index increases as the percentage of biomass load increases. The values obtained for the bio coal briquettes. The results obtained show that the physical properties of coal briquettes can be improved using maize cob biomass.

Coal in Indonesia is quite large spread almost throughout the islands of Indonesia, especially in Sumatra and Kalimantan. According to the data of about 86.11% is low grade. Research Center for Geotechnology in 2015 to do research, one of the study is the use of low-grade coal,as coal briquettes. Low grade coal, which is used from Cijambe area, Caringin Garut. To increase the calorific value and to improve the chemical and physical properties of briquettes, then we add fermented biomass. The study begins with characterization raw materials (coal and biomass), followed by making a formula to determine the optimum formula. Of this optimum formula, made coal-bio briquettes.

Table 9. Characterization of Coal and Fermented Biomass.

Analysis Parameters	Garut Coal (% , adb)	Biomass (% , adb)
Proximate		
Moisture in air dried sample	14.38	7.34
Ash	39.33	16.43
Volatile Matter	25.35	60.05
Fixed Carbon	20.94	16.18
Ultimate		
Carbon	30.20	40.65
Hidrogen	3.36	5.47
Nitrogen	tt	2.57
Total Sulfur	13.80	0.54
Oxygen	13.31	34.34
Gross Calorific Value (cal/g,adb)	2.646	3.891

Table 10. Calorific Value of Formulations for Bio-Coal Briquette.

No.	Formulasi Bahan Briket %			Nilai Kalor (cal/g, adb)
	Coal	Biomass	Binder	
1.	4	6	1	5.581
2.	5	5	1	4.077
3.	6	4	1	4.127
4.	8	2	1	3.957
5.	9	1	1	3.984
6.	10	0	1	3.874
7.	10	0	0	2.646
8.	0	10	0	3.891
9.	0	0	10	3.628

The optimum formula,which has a ratio of coal, biomass and binder 4:6:1. The formula has a calorific value of 5.581 cal/g.

Table 11. Proximate analysis of coal and Optimum Formula.

No	Coal:Biomass:Binder	Moisture %, adb	Ash %, adb	Volatile Matter %, adb	Fixed Carbon %, adb	Total Sulphur %, adb
1.	Garut Coal	14.38	39.33	25.35	20.94	13.80
2.	Optimum formula	10.17	16.91	49.52	23.40	2.13

From table 11, it is seen that the optimum formula is better than its own coal such as calorific value, moisture content, ash, fixed carbon and sulfur content.

3. Conclusions

Bio-coal briquettes are made from agriculture waste and coal, which are readily available, cheap and affordable. Researchers make these bio-coal briquettes with different aims and objectives, depending on the needs of each problem to be solved. Bio-coal briquettes produced for the purpose of finding alternative energy due to concerns about depletion and the high cost of fuel (BBM) or taking the idea to utilize agricultural waste because, much around us, cheap and environmentally friendly energy. The agricultural waste usually has a low calorific value, so to increase the calorific value of bio-coal briquettes, the researcher adds coal which has high calorific value. On the other hand, coal briquettes' physical properties can be improved by mixing agricultural waste. Our research is to make bio-coal briquettes to utilize low grade coal. In this case the coal is mixed with fermented biomass.

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