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Material Ratio Analysis of Charcoal Briquettes from *Dendrocalamus Asper Backer* Bamboo

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Abstract. The objective of this study proposes the best ratio of charcoal briquettes from 'Dendrocalamus Asper Backer' bamboo to make a comparison between heating value and environmental factors. A sample was selected from proportion of charcoal powder and cassava powder with 100:0, 95:5, 90:10, 85:15, 80:20, 60:40, 50:50. The proportion was used for data analysis using temperature machine, thermal gravimetric analyzer (TGA) and gross calorific value as ASTM 5865-04 standard. The results of present study were summarized as follows: 1) the best ratio is 90:10 with heating value 7419 cal/g, 2) higher charcoal powder higher heating value, 3) higher cassava powder higher smoke and soot.

1. Introduction

Thailand is an agricultural country with plenty of biomass [1]. Variety of material resources is used to produce energy such as sugar cane, straw, napier grass, or even agricultural waste. However, these materials are not enough for the energy requirements. Therefore, it has to find new potential resources of renewable energy with sufficient quantities.

Concerning to the demand of biomass fuels is increasing, the purpose of this study is to find suitable biomass resources for easy growing terrain and high potential for biomass production. Bamboo, from 'Dendrocalamus Asper Backer', can be applied for energy production.

The research study found that bamboo is the fastest growing plant in the world. This can grow at an average of 10 cm/day [2]. This is the main plant for production of environmentally friendly products, easily grown once cultivated for 70-80 years without replanting, high density, drought resistance and high heating value when compare with other local biomass materials [3-5]. Therefore, the researcher will find the optimal ratio for using as charcoal briquettes.



2. Research Methodology

2.1 Material

The main material is bamboo (*Dendrocalamus Asper Backer*) planting at “Jiraphan Bamboo Garden”, Yasothorn, Thailand. Average age is 0-5 years for main material and combust with 200 liters tank for increase high heating of material. Pyroligneous acid or wood vinegar is a by-product of charcoal burning that is the crude condensate of smoke generated during the process of making wood charcoal [5].

2.2 Charcoal to Charcoal Briquettes

- 1) Mash machine with 3 HP grinder hammer mill is used to mash charcoal into charcoal powder in order to give high heating and decrease smoke when it was burned.
- 2) Mixing charcoal powder and cassava powder with 5 HP mixer machine in ratios of 100:0, 95:5, 90:10, 85:15, 80:20, 70:30, 60:40, and 50:50.
- 3) Compressing charcoal powder and cassava powder with 5 HP conical screw press machine using standard diameter size 10 cm long and 1 cm hole.
- 4) Drying charcoal briquettes after compress to reduce moisture, increase heating value and make it hardly broken.

2.3 Experiment

Cutting 3 pieces of briquettes into 5 cm long and 1 cm diameter, and then heating samples using stove in 2 min to control heating value and time. After that, heating samples in 1000 ml of water for 3 h to find acceleration of heat and time of each ratio without addition of oxygen in combustion.

2.4 Performance Measurement

Analysis by temperature measuring sensors connect to computer as shown in figure 1.



Figure 1. Primary experiment and measurement

3. Results

We found that the best ratio of charcoal powder and cassava powder is 90:10 with high heating value, less smoke and smut. However, the content of cassava powder over 40 percent affects to stuck in output hole of machine. High heating acceleration belongs to charcoal powder proportion as shown in figure 2, combustion lifetime depends on cassava powder proportion at the expense of heating value.

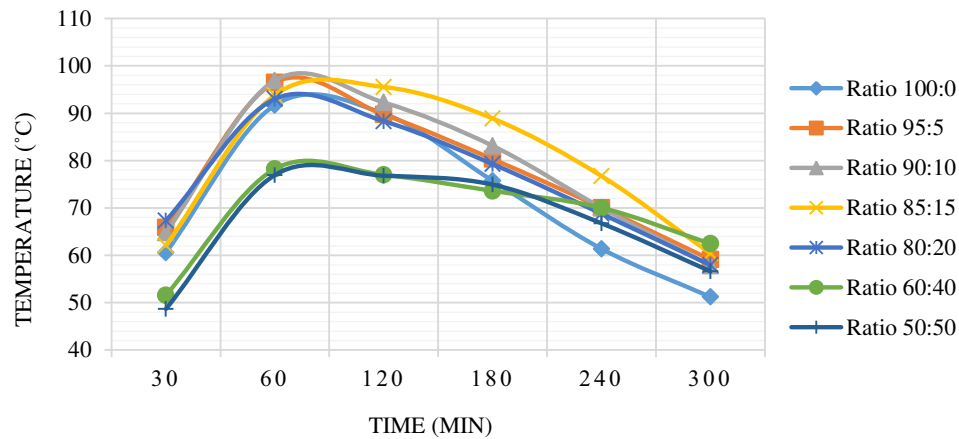


Figure 2. Heating comparison of samples

Fuel characteristics of each ratio in experiment present percentage of moisture, ash, volatile matter, fixed carbon and heating value (Cal/g) as shown in table 1. The best ratio is 90:10 compared to other local material briquettes in Thailand as shown in table 2 [6].

Table 1. Approximate analysis and heating value in experiment.

Ratio proportion	Moisture (%)	Ash (%)	Volatile Matter (%)	Fixed Carbon (%)	Heating Value (Cal/g)
Ratio 100:0	3.512	4.504	21.160	70.824	7,518
Ratio 95:5	2.830	3.215	24.371	69.584	7,408
Ratio 90:10	2.015	2.591	26.479	68.915	7,419
Ratio 85:15	2.005	2.614	27.488	67.893	7,389
Ratio 80:20	1.982	2.324	30.382	65.312	7,201
Ratio 60:40	1.975	2.412	35.402	60.211	6,918
Ratio 50:50	2.013	2.531	37.263	58.193	6,549

Table 2. Comparison between experiment and other material briquettes.

Biomass Type	Moisture (%)	Ash (%)	Volatile Matter (%)	Fixed Carbon (%)	Heating Value (Cal/g)
Dendrocalamus Asper Backer bamboo	5.8	2.7	71.7	19.8	4,203
Charcoal briquettes (Dendrocalamus Asper Backer bamboo) (Ratio 90:10)	2.015	2.591	26.479	68.915	7,419
Palm shell	12.12	3.66	68.31	16.3	4,413
Charcoal briquettes (Coconut shell)	7.13	3.74	13.47	82.79	7,276
Rice husk	12.5	12.73	56.98	18.88	3,499
Rice straw	10.12	10.42	60.87	18.8	3,173
Bagasses	50.76	1.75	41.99	5.86	2,308

Biomass Type	Moisture (%)	Ash (%)	Volatile Matter (%)	Fixed Carbon (%)	Heating Value (Cal/g)
Rubberwood	-	2.1	74.9	23	4,560
Charcoal briquettes (Rubberwood)	-	3.4	17.5	79.1	7,650
Charcoal briquettes (Rambutan wood)	3.415	3.932	21.815	70.838	7,059
Coal	-	7.7	42.8	49.5	5,860
Coke (fuel)	-	8.2	1.2	90.6	7,150

4. Conclusions

Group of charcoal briquettes ratio of 100:0, 95:5, 90:10, 85:15, 80:20 has better heating acceleration than those of 60:40 and 50:50 ratio. Actually, the proportion of maximum heating ratio should be the ratio with the highest number of charcoal powder. However, the 100:0 ratio experiment did not exhibit maximum heating during charcoal combustion. The lowest heating ratio in experiment was 50:50 as expected. The ratio of charcoal powder affects heating duration when cassava powder content is higher because cassava powder is burned slower than charcoal powder. Higher cassava powder content gives higher smoke and soot. During burning, the 100:0 ratio between charcoal powder and cassava powder has a bit smoke and soot but the 50:50 ratio has a lot of smoke and soot at the bottom of beaker. Soot color is dark brown and sticky.

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