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Research Article

Cost Analysis of Biomass Briquette Stove

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Abstract: The purpose of this research was to study the value investment of using biomass briquette stove instead of LPG cooking stove. From the previous study (Thuchayapong and Inthagun, 2015), the saw dust biomass briquette were produced and tested its physical properties. The biomass briquette stove was constructed and tested its thermal efficiency. In this research, the biomass briquette was improved its properties by changing binder from waste paper to cassava flour. It was found that the physical properties of moisture content, density and shatter index of sawdust briquette had been improved. In addition, the cost analysis of biomass briquette stove had been evaluated by comparison with the gas stove in the household. It was found that, the production cost of biomass briquette stove was 578 Baht and that of biomass briquette was between 1.63 to 2.33 Baht/kg. Net Present Value (NPV), Internal Rate of Return (IRR) and Payback Period (PP) were evaluated in this research. It was found that the biomass briquette stove was worth the investment.

Keywords: Biomass, Briquette Stove, Cost Analysis

1. Introduction

Biomass briquette stove was household appliances which used waste materials as biomass briquette fuel. There were many kind of waste materials such as fiber and shell of palm nuts in Malaysia (Husian et al, 2002), banana stem, and coffee husk in Nepal (Pandey and Regmi, 2013), rice husk and sawdust in Thailand (Chaiklangmuang et al, 2008), etc. In this investigation, sawdust was used as material for producing biomass briquette because it had low price and there was a lot of sawdust residues from furniture mills in the cutting, sawing and sanding processes. The kind of wood sawn timber, which were used in Thailand, were Teak, Redwood, and Selangan batu. Sawdust was a good alternative material for alternative energy resources because it had high heating value. The lower heating value (LHV) of sawdust was 19.5 MJ/kg [5] which enough for the fuel in household use. From the previous work (Thuchayapong and Inthagun, 2015, 2015) the waste paper was use as binder. It was a cheap material. But has some physical properties that are not good, especially the shatter index. In this research, the biomass physical properties was improved by using cassava flour as binder. Moreover, the cost analysis was evaluated in this research.

2. Methodology

2.1 Preparation of raw materials and the production of biomass briquette

The sawdust was collected from a furniture mill in Nakhon Pathom province, Thailand. It was mixed with waste paper and cassava flour as binders at the ratio of 5%, 10% and 15% by weight as shown in Fig 1 (a-c). The sawdust was densified in to briquettes with outer diameter of 4.5 in and inner diameter of 1.5 in by a 3 ton hydraulic bottle jack as shown in Fig 1 (d). Then, wet briquettes were dried in oven, as Fig. 1 (e), at 105 °C for 24 hours. The final weight of a briquette was between 200-220 g. After that, dried briquettes, as shown in Fig. 1 (f), were collected and sealed to prevent moisture.

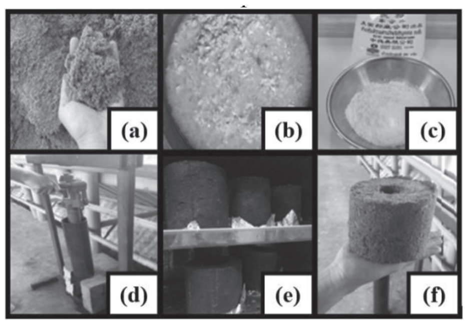

Fig.1: Raw material preparation and briquetting process

2.2 Testing of physical properties of biomass briquette

Physical properties of briquettes which included moisture content, density and shatter index were tested as follow.

2.2.1 Moisture content of briquettes

Moisture content of briquettes were determined by using ASTM D3173 (ASTM,). The empty crucible was heated under the temperature of 105 °C for 30 min. Then, crucible

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was cooled in desiccator for 15 min. After that, the sample of 1 g was put into crucible and heated at 105 °C for 20 min. The moisture content of sample could be calculated as follow,

$$M, \% = \frac{W_1 - W_2}{W_1} \times 100. \quad (1)$$

Where, M was moisture content, W_1 was sample used (1 g), and W_2 was of sample after heating (g).

2.2.2 Density of briquettes

Density of briquettes were determined by the ratio of mass to volume of dried briquette. It could be calculated by

$$\rho = \frac{m}{\pi h (r_o^2 - r_i^2)}. \quad (2)$$

Where, m was mass of briquette after heating (kg), h, r_o and r_i were height, outer radius, and inner radius of briquette (m), respectively.

2.2.3 Shatter index of briquettes

ASTM D3038 (ASTM,) method was used to determine shatter index. In drop shatter test, briquettes were dropped 3 times from a height 1.8 m to a concrete floor. The pieces of briquettes were sieved and the pieces with diameter longer than 20 mm were left on the sieve and weighed. The shatter index could be calculated as follow,

$$R, \% = W_f / W_i \times 100. \quad (3)$$

Where, R was shatter index, W_f was final weight of briquette with diameter longer than 20 than 20 mm (kg), and W_i was initial weight of briquette before drop (kg).

2.3 Construction of biomass briquette stove

The biomass briquette stove was constructed by steel plate and pipe. The dimensions were shown in Fig.2.

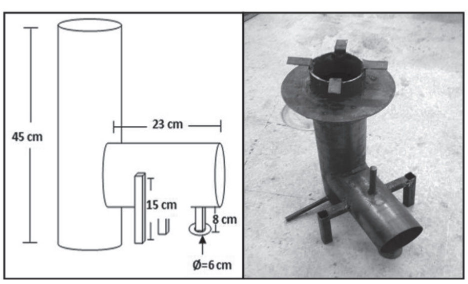

Fig.2: Biomass briquette stove

2.4 Cost Analysis

Cost analysis of biomass briquette stove was analyzed by comparison with using LPG cooking stove under these assumption,

From the previous study [1], thermal efficiency, LHV of fuel, price of fuel and costs of fuel per energy output were investigated as Table 1

Table 1 Comparison data [1]

Parameters	Biomass briquette stove	LPG cooking stove
Thermal efficiency	31.3%	29.0%
LHV of fuel	19.5 MJ/kg	46.6 MJ/kg
Price of fuel	1.75 Baht/kg	19.00 Baht/kg
Costs of fuel per energy output	0.29 Baht/MJ	1.40 Baht/MJ

The biomass briquette stove was used as alternative energy for household LPG gas stove. 15 kg LPG tank was uses for 2 tank/month with the price of 400 Baht/tank. The cost saving analysis was analyzed by using biomass to replace 50% of LPG.

The cost analysis was analyzed by the assumptions in Table 2.

Table 2 Initial assumption for cost analysis

Parameters	Value
Initial investment	578 Baht
Net energy cost saving	275 Baht/month
Discount rate	0.396%
Project life	1 year

Net present value (NPV), internal rate of return (IRR), payback period (PP) were calculated by assumptions in Table 2 for cost analysis.

The net present value was the difference between the present value of cash inflows and the present value of cash outflows over a period of time. It was calculated as follow,

$$NPV = -C_o + \sum_{t=1}^{n} \left[\frac{(B_t - C_t)}{(1+i)^t} \right]. \quad (4)$$

Where, C_o was initial investment, B_t and C_t were net cash inflow and outflows during a single period t, i was discount rate and was number of timer period, respectively.

The internal rate of return was a discount rate that makes the net present value of all cash flows from a particular project equal to zero. It was calculated by set NPV equal to zero and solve for the discount rate (r) as follow,

$$NPV = C_0 + \sum_{t=1}^{n} \left[\frac{(B_t - C_t)}{(1+r)^t} \right] = 0. \quad (5)$$

The payback period refered to the amount of time it takes to recover the cost of an investment. It was calculate as follow,

$$PP = \frac{\text{Initial Investment Cash}}{\text{Inflow per Period}}. \quad (6)$$

After NPV, IRR and PP were calculated, these indicators were used for investment decisions.

3. Results and Discussions

3.1 Physical properties of sawdust briquettes

3.1.1 Moisture content of sawdust briquettes

Fig.3 showed moisture content of sawdust briquettes. Waste paper and cassava flour were used as the binder with ratios of 5, 10 and 15% by weight. It could be seen that the briquettes with cassava flour binder had lower moisture content. It decreased from 3.40% to 2.50%, when the binder ratio increased from 5% to 10%. This showed that cassava flour binder can decrease moisture content. However, the moisture content of biomass with both binders were very low and could be used as fuel as well.

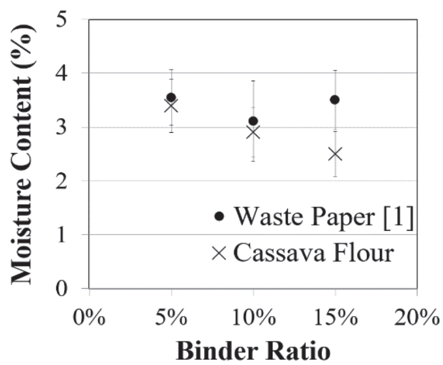

Fig. 3 Moisture content of sawdust briquette

3.1.2 Density of sawdust briquettes

Density of biomass briquette was an important parameter of fuel because the high density biomass briquette had very high energy and mass. Fig.4 showed density of sawdust briquettes with waste paper and cassava flour binders. It could be seen that the ratios of waste paper binder did not have effect on density of sawdust briquettes. But the density of biomass briquette increased from 313 kg/m^3 to 365 kg/m^3, when the binder ratio increased from 5% to 10%. This showed that cassava flour binder can increased density of biomass briquette.

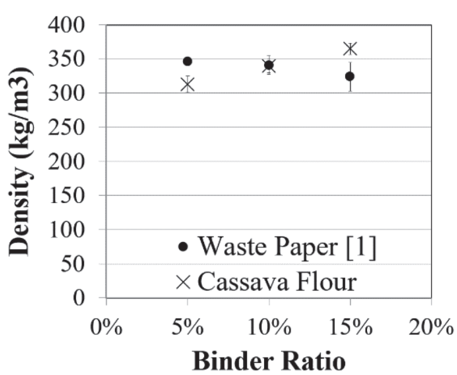

Fig. 4 Density of sawdust briquette

3.1.3 Shatter index of sawdust briquette

The shattered index was a parameter that showed the durability of the biomass briquette. The shatter index of briquette with waste paper and cassava flour binder were shown in Fig. 5. It could be seen that the briquettes with cassava flour binder had higher shatter index by comparison with waste paper binder. It increased from 84% to 98%, when the binder ratio increased from 5% to 10%. This showed that cassava flour binder can increased shatter index of biomass briquette.

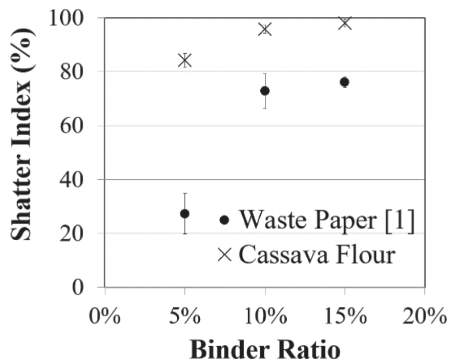

Fig. 5 Shatter index of sawdust briquette

3.2 Cost Analysis

From cost saving analysis, the biomass briquette stove was constructed and calculated its cost. The cost of stove was included of material and labor cost as shown in Table 3. It could be seen that the total cost was 578 Baht. This is the initial cost for biomass briquette stove.

Table 3 Initial cost for biomass stove

Cost	Price (Baht)
Steel Pipe	185
Heat Insulation	50
Labor cost	300
Other	43
Total	578

In addition, the biomass briquettes were produced and calculated its cost. The cost of briquette with both binder were shown in Fig. 6. It could be seen that even the biomass with cassava binder had better properties but its price is also higher. This is because the price of cassava flour is more expensive than waste paper.

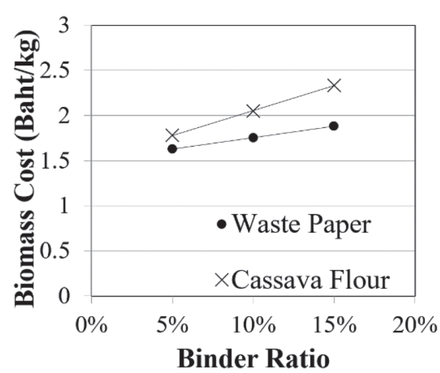

Fig.6 The cost of biomass briquette

From cost saving analysis, NPV, IRR and PP were evaluated by use assumption and data from Table 1-3. It was found that, NPV is 3,508 Baht, IRR is 609.7 % and PP is 1 month and 21 days. These showed that this project was worth the investment.

4. Conclusion

From the investigation, the physical properties of biomass briquette were improve by using cassava flour as binder. When the ratio of cassava flour increased, the moisture content was decreased while the density and shatter index were increased. The optimum ratio of cassava was 5% by weight because it had the moisture content of 3.4 %, density of 313 kg/m^3 and shatter index of 84% which enough for household cooking. From the cost analysis, the value for investment was evaluated by using the biomass briquette stove as alternative energy for household LPG gas stove. It was found that biomass briquette stove was worth the investment.

5. Acknowledgement

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