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Properties of solid fuel briquettes produced from rejected material of municipal waste composting

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Abstract

This research was conducted to determine the optimum mixing ratio for solid fuel briquettes produced by extrusion of rejected material of municipal waste composting char (MWCC) and sawdust char (SC). Experiments were performed on briquettes made from various ratios of rejected material of MWCC to SC: 100:0, 80:20, 60:40, 50:50, 40:60 and 20:80 by weight. Slop waste (either 10 %, 15 % or 20 %wt) was added as a binder. The solid fuel briquettes were formed into cylindrical shapes 3.8 cm in external diameter, 1.3 cm in internal diameter and 15 cm in length. The briquettes were evaluated for the following properties: moisture, ash, volatile matter, fixed carbon, calorific value, sulfur, combustion calorific value, compressive strength, water resistance, and bulk density. The experimental results indicated that calorific value and combustion calorific value of the solid fuel briquettes increased with increasing ratios of sawdust char. Compressive strength, water resistance and bulk density of the solid fuel briquettes also increased, and depended both on increased ratios of sawdust char and on a higher percentage of binder. From the research results, it can be concluded that a MWCC to SC ratio of 20:80 with 20% slop waste was most suitable for production of solid fuel briquettes. This study demonstrates that the rejected material of municipal waste composting can be used as an alternative fuel for industrial use. This will not only promote the reuse of waste material for optimal benefit, but will also reduce the use of landfill space.

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Keywords: solid fuel briquettes, reuse of waste material, recovery

1. Introduction

The principles of solid waste handling include many methods, such as incineration, sanitary landfills, and municipal waste composting. However, incineration and sanitary landfills have adverse environmental impacts. Thus, nowadays the focus of solid waste handling is to reduce the quantity of

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solid wastes. Composting of municipal waste is a widely used method, but it involves the subsequent handling of rejected material. The rejected material consists of a large amount of resistant organic matter that cannot be transformed in the composting process and must be disposed of. Therefore, if it can be utilized to produce beneficial things such as solid fuel briquettes[1], it will significantly reduce unnecessary use of landfills.

1.1 Experiment

The experiment process of producing solid fuel briquettes (using a binder) was as follows:

- Rejected material of municipal waste composting and sawdust were exposed to the open air.
- Raw materials were carbonized in a limited-air vessel with a capacity of 200 L. Twelve kg of rejected material of municipal waste composting and 10 kg of sawdust (a total of 1/5 of the vessel capacity) were placed into the carbonization vessel (pictured in Fig. 1). The times required to carbonize rejected material of municipal waste composting and sawdust were 6 h and 4 h, respectively.

Fig. 1. Carbonization vessel

- The resulting rejected material of municipal waste composting char (MWCC) and sawdust char (SC) were ground and then sifted using an ASTM sieve no. 4 (pore size 4.75 mm). Char that could pass through the sieve was used in this research.
- Various ratios of MWCC to SC – 100:0, 80:20, 60:40, 50:50, 40:60 and 20:80 by weight – were used to create briquettes for testing. Slop waste (10%, 15% or 20%wt) was added as a binder.
- The briquettes were formed by an extruder (see Fig. 2) into a cylindrical shape 3.8 cm in external diameter, 1.3 cm in internal diameter and 15 cm in length. Then the briquettes were dried in the open air for 7 d.

The resulting solid fuel briquettes (shown in Fig. 3) were evaluated for the following properties: moisture, ash, volatile matter, fixed carbon, calorific value, sulfur, combustion calorific value, compressive strength, water resistance, and bulk density.%

Fig. 2. Extruder

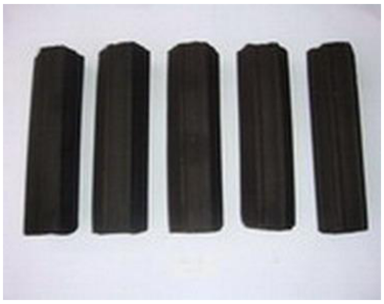

Fig. 3. Solid fuel briquettes

1.2 Results and Discussion

1.2.1 Proximate analysis

Proximate analysis[2] is a method of analyzing moisture[3], ash[4], volatile matter and fixed carbon. Results of raw material testing are reported in Table 1, and test results of solid fuel briquettes in Table 2. The results indicate that both the rejected material of municipal waste composting and sawdust have higher moisture, ash and volatile matter content than solid fuel briquettes, but less fixed carbon. As shown in Table 2, fixed carbon content increased with increasing ratios of sawdust char. The Thailand Industrial Standards Institute mandates that the moisture content of solid fuel briquettes not exceed 8% by weight (Thailand Industrial Standards Institute, Ministry of Industry, 2002)[5],[6]. The solid fuel briquettes used in this research had moisture content lower than this standard.

Table 1: Analysis of raw materials

Parameter	Sample	
	Rejected material of municipal waste composting	Sawdust
Moisture (%wt/wt)	8.69	6.74
Volatile matter (%wt/wt)	69.76	67.43
Ash (%wt/wt)	10.77	6.12
Fixed carbon (%wt/wt)	10.78	19.71
Calorific value (cal/g)	2195	3425
Sulfur (%wt/wt)	0.67	0.56

Table 2: Proximate analysis of solid fuel briquettes

Parameter	Ratio					
	100:0	80:20	60:40	50:50	40:60	20:80
Moisture (%wt/wt)	5.88	5.70	5.15	5.08	4.75	4.65
Volatile matter (%wt/wt)	63.94	62.34	61.94	57.35	56.77	54.82
Ash (%wt/wt)	14.39	13.61	12.46	11.36	10.59	9.84
Fixed carbon (%wt/wt)	15.79	18.35	20.45	26.21	27.89	30.69

1.2.2 Calorific value and sulfur content as measured by a bomb calorimeter

Table 1 shows that the calorific values[7] of rejected material of municipal waste composting and sawdust were 2195 and 3425 cal/g, respectively, as measured by a bomb calorimeter. Fig. 4 illustrates that the calorific value of solid fuel briquettes increased, depending on increasing ratios of sawdust char. The 20:80 ratio of rejected material of MWCC to SC had the maximum value, 5,359 cal/g, which was higher than the Thai Industrial Standards Institute requirement of not less than 5,000 cal/g.

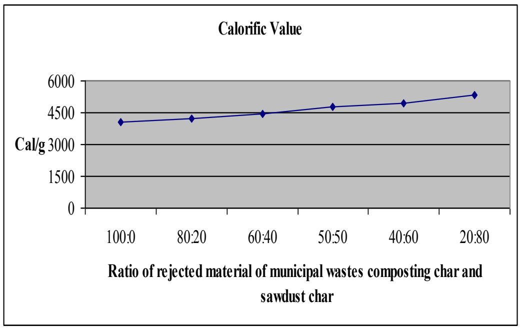

Fig. 4. Calorific value measured by a bomb calorimeter

Sulfur contents[8] of the raw materials were 0.67 and 0.56%wt/wt for rejected material of municipal waste composting and sawdust, respectively (see Table 1). As shown in Fig. 5, solid fuel briquettes of every ratio had sulfur content of 0.39–0.44%wt/wt – lower than that of the raw materials, and meeting the specifications of the Thailand Industrial Standards Institute that the sulfur content of solid fuel briquettes is not exceed 5% by weight.

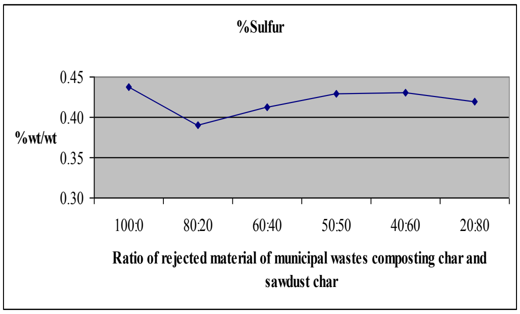

Fig. 5. Percentage of sulfur measured by a bomb calorimeter

1.2.3 Combustion calorific value

Combustion calorific[9] value indicates the heat that can be generated by burning solid fuel briquettes. The high combustion calorific value indicated that solid fuel briquettes can provide sufficiently high heat for industrial production processes. Fig. 6 illustrates that the combustion calorific value of solid fuel briquettes increased with increasing ratios of sawdust char. The maximum value was 829.55 cal/g for the ratio 20:80. Another factor that can indicate the quality of solid fuel briquettes is the burning time. As shown in Fig. 7, the burning times increased along with increasing proportions of sawdust char. The 20:80 ratio of rejected material of MWCC to SC had a maximum value of 211 min.

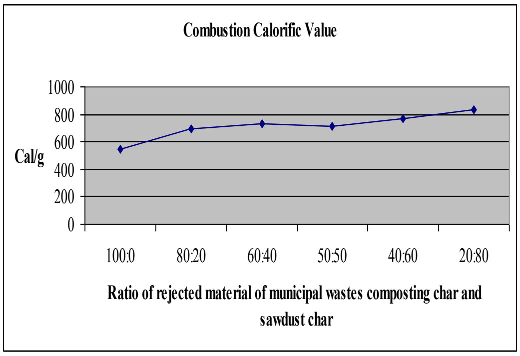

Fig. 6. Combustion calorific value

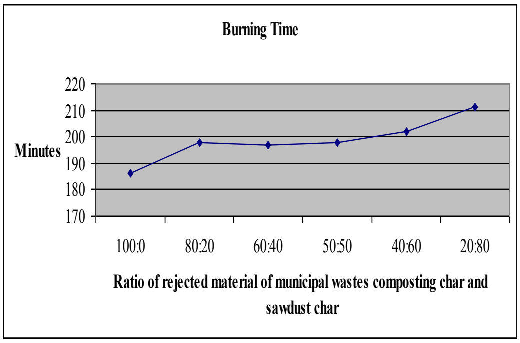

Fig. 7. Burning time

1.2.4 Compressive strength

The acceptable compressive strength in industry is 0.38 MPa (Richard, 1990)[10]. Compressive strength testing showed that all ratios of the solid fuel briquettes exceeded this standard, and hence would not break easily during transport or storage. As shown in Fig. 8, compressive strength increased depending on increasing ratios of sawdust char, as well as on an increasing percentage of binder. A 20:80 ratio of rejected material of MWCC to SC, with the addition of 20%wt of slop waste as a binder, had the highest compressive strength, 2.00 MPa.

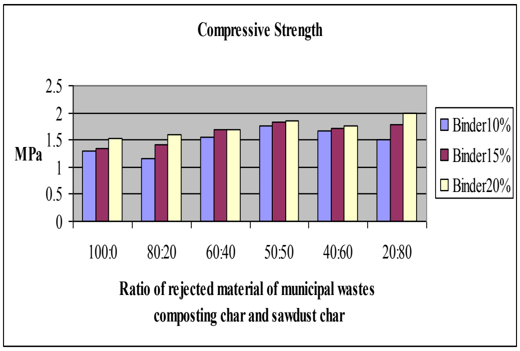

Fig. 8. Compressive strength

1.2.5 Water resistance

Water resistance[11] is a value of showing the resistance of solid fuel briquettes to moisture or water penetration during transport or storage. High water resistance is a desirable quality which enables briquettes to remain impermeable to water for a long period of time before losing their shape. Fig. 9 illustrates that the water resistance of solid fuel briquettes increased with increasing proportions of sawdust char and with an increasing amount of binder. The highest water resistance – 136 min – was found in briquettes with a ratio of rejected material of MWCC to SC of 20:80, and with the addition of 20%wt of slop waste.

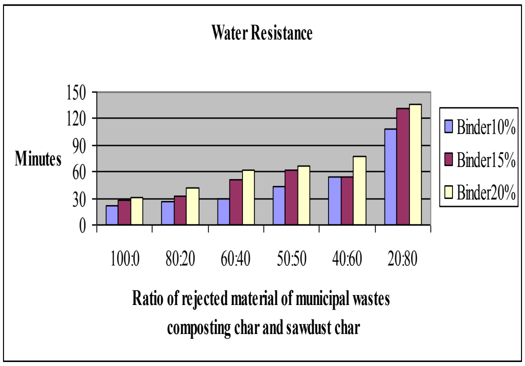

Fig. 9. Water resistance

1.2.6 Bulk density

Bulk density[12] is a value which shows the weight per volume of solid fuel briquettes, and can help estimate their heat or strength. High bulk density is therefore a desirable value. As seen in Fig. 10, bulk density increased with increasing ratios of sawdust char and with a higher percentage of binder. At a 20:80 ratio of rejected material of MWCC to SC, the addition of 20 %wt of slop waste as a binder resulted in the highest bulk density, 1.24 g/cm^3.

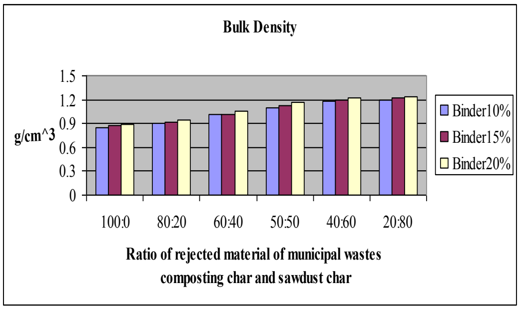

Fig. 10. Bulk density

Conclusion

From the experimental properties of solid fuel briquettes produced from rejected material of municipal waste composting char (MWCC) and sawdust char (SC), the following conclusions can be made:

1. Rejected material of MWCC can be used to produce solid fuel briquettes.
2. Mixing SC into solid fuel briquettes can favourably adjust the properties of solid fuel briquettes, and is an improvement over using only rejected material of MWCC.
3. A 20:80 ratio (by weight) of rejected material of MWCC to SC had the highest calorific value, sulfur content, combustion calorific value, and burning time.
4. The further addition of 20%wt of slop waste to the 20:80 ratio of MWCC and SC resulted in the highest compressive strength, water resistance, and bulk density.
5. The solid fuel briquettes consisting of a 20:80 ratio of MWCC to SC, with the addition of 20%wt of slop waste, met all industry production standards.

6. Therefore, rejected material of MWCC is suitable for manufacturing solid fuel briquettes for industrial use.

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