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Application of a gas–solid fluidized bed separator for shredded municipal bulky solid waste separation

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Abstract

A laboratory-scale gas–solid fluidized bed separator able to separate fractions of 5.6–50 mm was used for separation of shredded municipal bulky waste (SBW) into combustibles and incombustibles. In batch-scale tests, it was found that accumulation of SBW in the bottom of the bed significantly reduced the separation efficiency. In this study, stirring was shown to be effective in preventing this accumulation. Flexible sheet materials such as paper and film plastics also significantly decreased the separation efficiency. In batch-scale tests, an overall efficiency of 90% was obtained when flexible materials such as film plastics and paper were excluded from the feed SBW. In continuous feeding tests, purities of the float and sink fractions attained 95% and 86% efficiencies, respectively, with an overall efficiency of 79%. The effect of feedstock shape on separation efficiency was also investigated. This study revealed that large particles can be properly separated on the basis of density, while the shape of the material significantly influenced behavior in the fluidizing bed.

1. Introduction

Bulky waste is source separated and shredded in resource recovery facilities in most municipalities in Japan to reduce the volume of waste landfills. After ferrous and non-ferrous metals are recovered, shredded bulky waste (SBW) is separated into overflow and underflow fractions by vibrating or trommel screens. By supposing that the main components of the overflow and underflow are combustibles and incombustibles, respectively, the former fraction is incinerated while the latter is directly landfilled. However, the underflow was shown to have high ignition loss up to 50% due to the high percentage of wood, paper, and plastics (Sekito et al., 1997). For better operation and management of MSW landfills, alternative separation techniques with higher efficiency are therefore desirable.

Beunder et al. (2002) used shape separation with a rotating cone to recycle demolition waste and waste glass. In this technique, materials are separated by differences in their movement or trajectory on a sloped board, for instance, spherical particles move far on the board. However, the shape of SBW varies even when it has a uniform composition. In particular, the shapes of metal and glass particles vary widely from spheres to bar- or plate-shapes (Sekito et al., 2003). Shape separation would be inefficient for separation of SBW.

Liquid separation has been studied and developed for plastic waste separation (Shen et al., 2002). However, it is disadvantageous in that a drying process and wastewater treatment are needed, which makes the process expensive. Dodbiba et al. (2003) used an air-table separator to separate plastics (PP and PVC), but separation of SBW using this method is difficult because light paper and film plastics scatter out from the table. Air classification has been developed for MSW separation by several researchers (e.g., Everett and Peirce, 1990; Stessel and Peirce, 1986) but, of the waste components in SBW, the terminal velocity of plastics overlapped with those of glass and metals as shown in Table 1 (Sekito et al., 2003). Everett and Peirce (1989) also reported that the separation of plastics and aluminum was difficult using an air classifier. On the other hand, Tanaka et al.

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Table 1
Particle density and terminal velocity of each SBW fraction (Sekito et al., 2003)

	Density		Terminal velocity	
	g/cm^3	Standard deviation	m/s	Standard deviation
Foam plastics	0.04	0.02	2.3	0.3
Paper	0.15	0.11	2.4	0.7
Wood	0.42	0.11	4.8	1.0
Plastics	1.11	0.18	7.7	1.5
Rubber	1.15	0.33	9.4	2.4
Glass	2.50	0.36	13.9	2.2
Metal	5.03	1.82	14.6	4.7

(2000) used a gas–solid fluidized bed separator, in which material is separated by density, to improve the quality of coal. The technique was modified by Oshitani et al. (2003) to successfully separate plastics and copper wire in automobile shredded residue at a Cu purity of 90% or higher.

The purpose of this study is to investigate whether the gas–solid fluidized bed separator can be used for separation of SBW in continuous operation. SBW of 5.6–50 mm was fed into a lab-scale separator equipped with screw collectors for float and sink fractions, respectively. Then the effects of the shape, volume, and composition of the feedstock on separation efficiency were investigated. Finally, the applicability of the technique on a real scale was discussed.

2. Materials and methods

2.1. Characteristics of SBW samples

SBW samples were obtained from three MSW shredding facilities. In Facilities A and B, incombustible bulky waste only is shredded and then separated into overflow and underflow fractions using a vibrating screen after ferrous metal is recovered using a magnetic separator. In Facility C, on the other hand, incombustible waste such as waste glass and metals are processed in addition to bulky items. The waste is shredded using a hammermill, and sieved through a trommel screen after recovery of aluminum and ferrous metals. The material flows at the facilities are described in Table 2.

Sampling was carried out several times in each facility. Overflow and underflow fractions were sampled at Facilities B and C, and mixed according to the ratio of annual generation. In Facility A, samples were taken before screening. Combustible bulky waste, which is shredded using a shearing cutter in Facilities A and B, was not included in this work.

Particle size distributions and physical compositions of particles of 5.6 mm and over are shown in Figs. 1 and 2, respectively. Composition was determined for dried samples, and average values are shown in Fig. 2. Compositions differed between the samples from Facilities A and B although the input waste was almost the same. Wood was contained in SBW from Facility A, while foam plastics were found in that from Facility B. SBW from Facility C

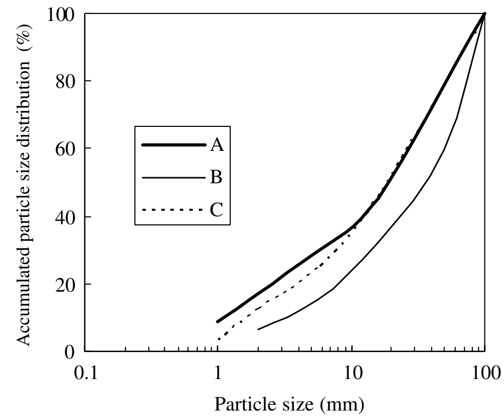

Fig. 1. Particle size distribution.

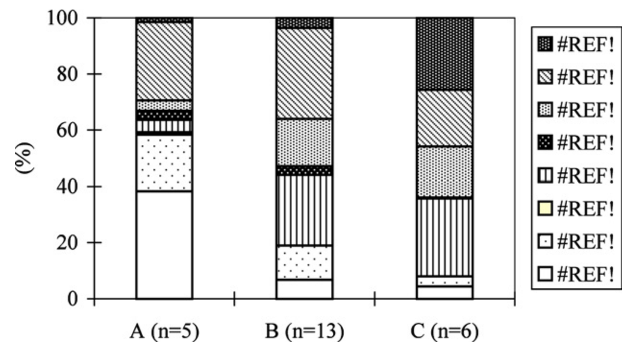

Fig. 2. Physical composition of SBW over 5.6 mm obtained from three resource recovery facilities. SBW A was obtained from Facility A in 2002, SBW B from Facility B in 1995, and SBW C from Facility C in 1995 and 2002. The results were averaged; "n" indicates the number of samples obtained.

was characterized by a large portion of glass. In the following experiments, SBW from Facility A was used because it could be sampled before screening.

Five series of experiments were carried out. In RUN 1, model particles of different shape were used, and the shape effect on separation efficiency was studied. In RUNs 2–5, SBW between 5.6 and 50 mm from Facility A was used because the composition of the small particles could not be identified, and the large particles were excluded due to the separator size. Test samples were prepared by mixing sorted material to simulate the original composition of SBW; however, the incombustible fraction in SBW from Facility A was very small (Fig. 2), so glass particles between 5.6 and 50 mm from Facility C were included to give an equal amount of combustibles and incombustibles, allowing examination of the recovery rate of the heavy fraction. The compositions of the test samples for each experiment are shown in Table 3. In RUN 3, the bed was stirred to improve separation; in RUN 4, paper and film plastic fractions that reduce separation efficiency were excluded; and in RUN 5, SBW samples were fed continuously.

In RUN 1, model samples with three different shapes (bar-shaped, plate-shaped, and cubed), four densities (0.5,