Title:
Newly developed discharge device for jig separation of plastics to recover higher grade bottom layer product

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Key words:
jig, discharge device, plastics, bottom layer product

Abstract

The jig is efficient in separating relatively low density particles such as plastics; however conventional discharge devices attached to jigs cause mechanical disruption of the stratified layers at the outlet from the separation chamber, and decrease the grade of the recovered bottom layer product. A new device was developed for efficiently separating high grade of bottom layer product, better than 99 %, where particles of the bottom and top layers are recovered as overflow products by agitation with water pulsation.

1. Introduction

Jig separation is a common gravity concentration method in mineral processing and today it is in widespread use because of its high separation efficiency, cost effectiveness, and high throughput rate (Kelly and Spottiswood, 1982; Wills, 1992; Buntenbach et al., 1997; Tsunekawa et al., 2005a). The TACUB jig (Takakuwa and Matsumura, 1954) used here is an excellent separator for relatively low density particles such as plastics because adjusting and controlling water pulsation conditions are simple (Tsunekawa et al, 2005b,c). To further improve the separation efficiency, the TACUB jig was modified as the RETAC jig to control conditions more accurately and it was further evolved into a “hybrid jig” (Hori et al., 2009; Ito et al., 2010b) and a “reverse jig” (Ito et al., 2010a, b). The hybrid jig, the RETAC jig with an air bubbler under the particle bed, can separate plastics having similar densities using differences in surface wettability of the feed produced by a pretreatment. The reverse jig is a RETAC jig equipped with a top screen and discharge devices to separate plastics lighter than water.

Mechanical extractors such as rotating extractors are used to recover particles of the bottom layer in the RETAC and hybrid jigs. When the specific gravity of particles is less than 1.5, stratified bottom layers at the outlet from the separation chamber are disturbed by the extractor, decreasing the grade of the recovered bottom layer products. This paper describes a newly developed device, by which particles of the stratified bottom layer are moved by the water pulsation in the jig separator and recovered as overflow product of high grade from a specially equipped bottom product recovering chamber, and particles of the top layers overflow and are recovered from the separation chamber.

2. Experimental

2.1 Materials

Feed plastics used in the verification experiments here were polyvinyl chloride (PVC) and polycarbonate (PC), all in cylindrical shape of 2-3 mm length and diameter. The specific gravities of the PVC and PC, measured

by the Ultra Pycnometer (Yuasa Ionics Co., UPY-14L), were 1.49 and 1.20, respectively. The PC - PVC mixture (1:1 mixture, mass basis) was used as feed for the jig experiments.

2.1.1 Jig separation experiments using a conventional RETAC jig

The bench scale continuous RETAC jig (R&E Co., Japan) shown in Fig. 1 was used for separation of the PC-PVC mixture. The dimensions of the separation chamber are: height 550 mm, width 150 mm, and length 450 mm. The mixture was fed into the separating chamber at a constant rate using a vibrating feeder. Top layer products overflow from the separation chamber by the agitation induced by water pulsation, and bottom layer products are extracted by the rotating extractor.

Jig experiments were conducted under conditions of 30mm displacement and 30/min frequency, where the average residence time of feed particles was controlled to be 715 s and 770 s. At a steady state of jig operation, both the top and bottom layer products were sampled, and then the operation was stopped for sampling of the particle bed in the separation chamber. After draining water from the jig, the chamber was divided into 4 zones, A to D, as shown in Fig. 1; zone A (0-15 cm), zone B (15-25 cm), zone C (25-35 cm), and zone D (35-45 cm) measured from the feed side wall. The samples in the four zones were obtained from the bottom layer products at 5 cm above the screen, and the specific gravity of the samples, and of the top and bottom layer products were measured to determine the grades.

2.2.3 Jig separation experiments using the RETAC jig with new discharge device

As shown in Fig. 2, the newly developed discharge device is installed by setting a partition at 30cm from feed side wall and with 1cm clearance above the screen. The particles of the bottom layer in the separation chamber move to the compartment through the clearance by water pulsation and flow.

Jig experiments for the PC – PVC mixture were conducted under conditions of 30mm displacement and 30/min frequency, where the average residence time of feed particles was controlled to be a desired value by adjusting feed rates. At a steady state of jig operation, both the top and bottom layer products were sampled and the specific gravities were measured to

determine the grades.

3. Results and discussion

Fig.3 shows the separation results of the PC-PVC mixture using the conventional RETAC jig. When setting the average residence time of feed particles to 715 s, the PVC grade of the bottom layer in the separation chamber increased from 97 % at the A zone to 99 % at the C zone, then decreased to 97 % at the D zone. The grades of recovered product were 94 % PVC for the bottom layer and 98 % PC for the top layer. By extending the residence time to 770 s, the PVC grade of the bottom layer from the A to C zone was 99 %, unchanged, but decreased to 97 % at the D zone, and finally the 94 % PVC grade of the bottom layer product and the 99 % PC of the top layer product were recovered. These results indicate that the feed particles are rapidly stratified in the A zone, and that the grade of stratified layers increase gradually from the feed side wall to the discharge side, where top layer particles overflow and are recovered as the top layer product, maintaining a higher PC grade. Because PC and PVC particles are not heavy, both kinds of particles can move easily by water pulsation and water flow. When extracting the bottom layer particles of stratified layers by the rotating extractor, the stratified layer at the end of the separation chamber is slightly disrupted. As a result, the PVC grade of the bottom layer product decreased.

For recovering a higher PVC grade of bottom layer product, a new discharge device was developed as shown in Fig. 2. Here water pulsation and flow are used to advance particles of the stratified layer and there is no mechanical extractor. Table 1 shows the jig separation tests for the PC-PVC mixture using the new device at different average residence times. Top and bottom layer products better than 99% grade were recovered at the short average residence times of 330 s. As the discharge device is simple and needs no complex installation, it is expected that the device will be an effective extractor for jig separation of light particles.

4. Conclusions

The authors have developed a new device for attachment to a jig separator to recover light particles such as plastics. Conventional discharge devices attached to jigs cause mechanical disruption to the stratified layers at the outlet from the separation chamber, and decrease the grade of recovered bottom layer product. With the new device water pulsation and flow are used to advance particles of the stratified layer and there is no mechanical extractor. The jig separation tests of PC-PVC mixture using the device were carried out, and the top and bottom layer products better than 99% grade were recovered.

Acknowledgement

The authors gratefully acknowledge the financial support provided by Japan Society for the Promotion of Science.

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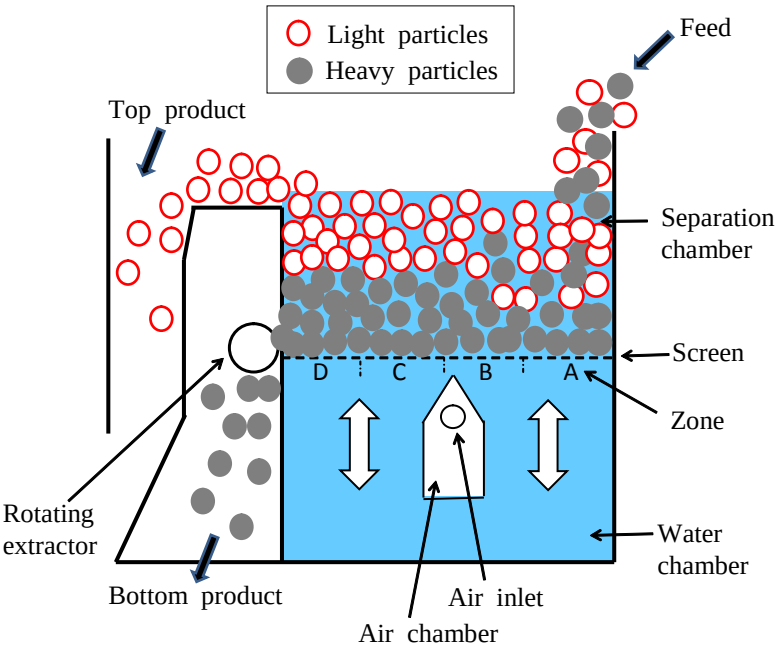

Figure 1: Outline of conventional RETAC jig.

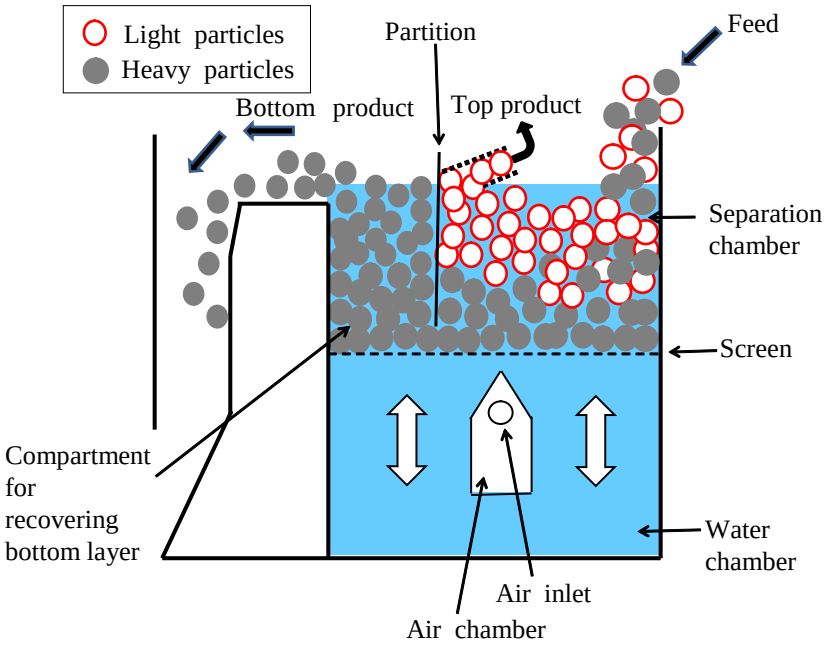

Figure 2: Outline of RETAC jig with new discharge device.

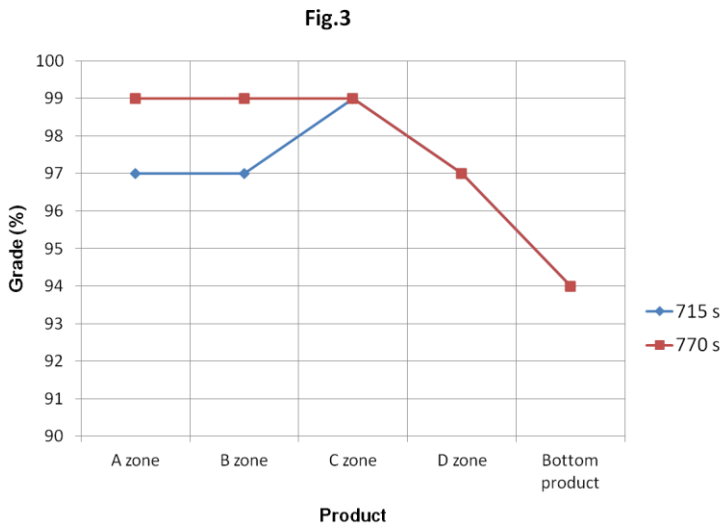

Figure 3: Grades of bottom layers in different zones of the separation chamber and grades of bottom products using a conventional jig at average residence times of 715 and 770 s.

Table 1 Jig separation tests of PC-PVC mixture using new device at different average residence times

Average residence time(s)	PC grade(%) of top product	PVC grade(%) of bottom product
330	99	99
408	99	99
444	99	99
602	99	99