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# Jig Separation of Plastic Waste Used in Copy Machines

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A TACUB jig was applied to separate waste plastics [polystyrene (PS), acrylonitrile butadiene styrene (ABS), and polyethylene terephthalate (PET)] used in copy machine. The effect of water pulsation including amplitude and frequency on the separation performance was investigated for the feeds containing two or three plastics. Good results are obtained under suitable conditions. Grades of 99.8% PS, 99.3% ABS, and 98.6 % PET are recovered as the products in the upper, middle and bottom layers respectively. Based on these results, a processing plant for recycling of plastics from scrapped copy machines is now under construction.
Keywords: Plastics, Jig Separation, Copy Machine, Recycling Plant.

## Introduction

Innovations and modifications in office machines are frequent and result a large number of scrapped copy machines and computers due to replacement. These scrapped machines contain valuable materials, which should be recycled and reused. In conventional treatment plants of scrapped copy machines, only printed wiring boards, photosensitive drum and a part of plastics are hand-picked to recycle. However, most of the other materials are shredded to discard as landfills. Our investigation on typical copy machines shows that the main components are about 50wt% iron and 20-25wt% plastics. The plastics include 48wt% acrylonitrile butadiene styrene (ABS) and 47wt% polyolefines such as polystyrene (PS), polyethylene (PE) and polypropylene (PP). Because iron and plastics have different magnetic properties and specific gravities, they are effectively separated by magnetic and gravity separation. However mechanical separation of different plastics with similar physical properties is not so easy and open an important area for technology development in planning and constructing an automatic recycling process for scrapped copy machines.

Jig separation is one of the oldest methods of gravity concentration. Even today it is the widespread technology in coal preparation because of its high separation precision, cost-effectiveness and high throughput rate [1-3]. As the separation density can be selected in wide ranges corresponding to feed composition, jig technology is often applied to utilize the solid wastes [4]. In the present study, mechanical separation experiments on plastics used in copy machines were carried out using a TACUB jig developed by professor emeritus Takakuwa of Hokkaido University [5] and it was found that jigging is an effective technology for separation of plastics.

## Experimental

### *Materials*

The three plastics, PS, ABS and PET (polyethylene terephthalate), were hand-picked from copy machines and cut, then ground and sieved to obtain (–10+3.5) mm fraction. These were washed with water containing a small amount of hand soap for removing surface contamination. The specific gravities of PS, ABS and PET were found to be 1.03, 1.22 and 1.71 respectively.

Zinc chloride was used to produce the dense mediums by dissolving in water.

### *Methods*

Jig separation experiments were carried out using the TACUB jig shown in Fig. 1, where a special cell was used to conveniently feed and recover binary or ternary plastic mixtures into/from the separation chamber. The bottom (109Lx109W mm) of the cell is made of stainless steel screen and the front side is a polymethyl methacrylate plate movable up and down.

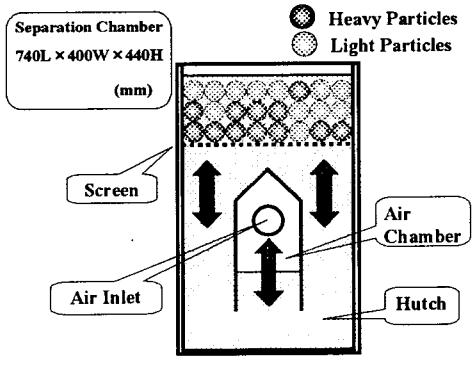


Fig. 1 Outline of TACUB jig.

The plastics of equal weight were mixed together to prepare the feed mixtures, then 300g of binary mixture or 360g of ternary mixture was put to form a bed in the cell. The cell was set and hold for a predetermined time in the separation chamber of the jig, which was operating under a desired water pulsation. The mixture of plastic particles in the bed was stratified as a result of periodic dilation of the bed through the action of pulsating currents of water. After the experiment, the stratified particles at different bed heights in the cell were recovered by sliding the front plate and the products of three layers for binary mixture and five layers for ternary mixture were obtained. The top layer is called upper layer for both mixtures and the third layer from top is named middle layer for the ternary mixture. Using dense mediums, the products were separated into individual plastic groups, then dried and weighed to calculate the product grades.

## Results and Discussion

The major operating variables that affect the stratification in a jig are amplitude and frequency of pulsation, waveform, bed thickness and feed quality. Because the waveform of water in the jig used is fixed to be a sine curve, the effects of the variables except waveform on plastic separation were investigated.

### *Separation of Binary Mixtures*

Figures 2 and 3 show the effects of pulsation amplitude on the separation of PS/ABS mixture, where the jig was operated at a frequency;20 cycles/min, bed thickness; 6 cm and water level; 8 cm. The water level indicates the lowest position of the pulsation from the screen of the cell. With increasing total pulsation number, PS (light particles) and ABS (heavy particles) are moved to upper and bottom layers respectively and stratified. The amplitude has an opposite effect on the grade of both the layers. ABS grade of bottom layer is increased with decreasing the amplitude, but the highest PS grade of

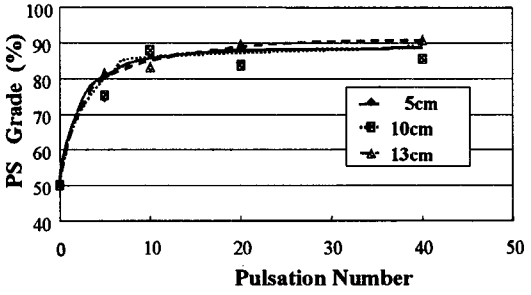


Fig. 2 Effect of pulsation amplitude on PS grade of upper layers at frequency; 20 cycles/min and bed thickness; 6 cm.

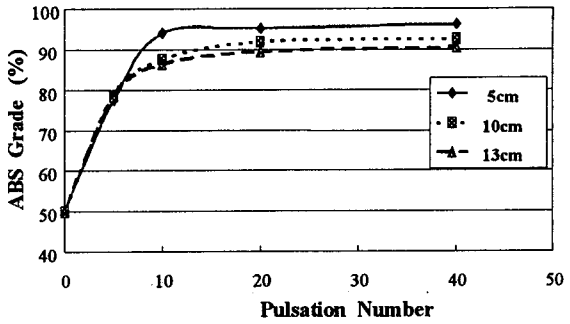


Fig. 3 Effect of pulsation amplitude on ABS grade of bottom layers at frequency; 20 cycles/min and bed thickness; 6 cm.

upper layer is obtained with amplitude: 13 cm at total pulsation number: 40. These results suggest that there are optimum amplitudes for dilation and stratification of the bed.

Pulsation frequency also affected the separation of PS/ABS mixture as shown in Figures 4 and 5, where the jig was operated at an amplitude;10 cm, bed thickness; 6 cm, water level; 8 cm and total pulsation number; 70. ABS grade of bottom layer is increased with decreasing the frequency and 99% ABS product is obtained at a frequency:10 cycles/min. However, the PS grade of upper layer is practically unaffected by changing the frequency and 99-98% PS of products are recovered at all frequencies. The amplitude of 10 cm is sufficient to dilate the bed and a good stratification is achieved after enough total pulsation number. Under amplitudes able to dilate the bed, the decrease in frequency gives the time necessary for differential settling of ABS particles, and consequently, ABS grade of bottom layer becomes higher.

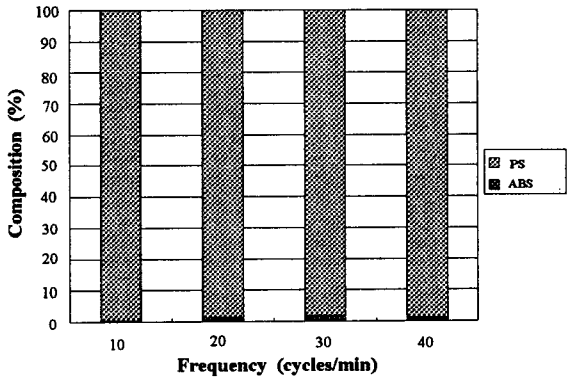


Fig. 4 Effect of pulsation frequency on PS grade of upper layers at amplitude; 10 cm, bed thickness; 6 cm of and total pulsation number; 70.

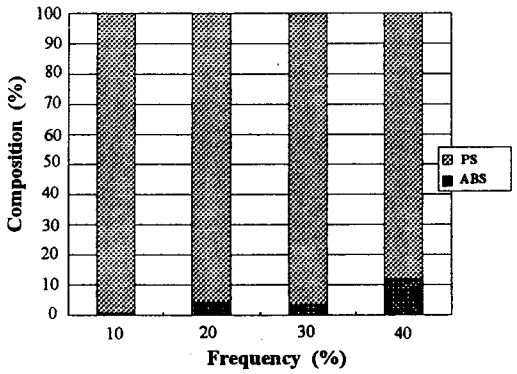


Fig. 5 Effect of pulsation frequency on ABS grade of bottom layers at amplitude; 10 cm, bed thickness; 6 cm and total pulsation number; 70.

As the bed became thicker, critical amplitude and pulsation number needed for dilation and stratification of the bed is increased. When the bed thickness is 22cm corresponding to 1,300 g of feed, the amplitude larger than 7cm is required. Using this feed, 99.9% PS of upper layer product and 96.3% ABS of bottom layer product are obtained at an amplitude;7 cm, frequency;20 cm, water level; 27cm and total pulsation number; 100.

*Separation of Ternary Mixtures*

Jig separation experiments of ternary mixtures containing PS, ABS and PET were carried out to investigate the effects of main operation variables.

Figures 6-8 show the effects of pulsation amplitude on the grade of products, where the jig was operated at a frequency; 40 cycles/min, bed thickness; 6 cm, water level; 12 cm and total pulsation number; 50. The PS grade of upper layers is higher than 99% at all amplitudes. With decreasing amplitude ABS grade of middle layers and PET grade of bottom layers are increased and reached 96.7% and 99.2% respectively at an amplitude: 4 cm. These results suggest that an excessive large amplitude disturbs the stratification of PET (heavy particles) and ABS (intermediate density particles).

Figures 9-11 show the effects of pulsation frequency on the grade of products, where the jig was operated at an amplitude; 4 cm, bed thickness; 6 cm, water level; 12 cm and total pulsation number; 50. The PS grade of upper layers is unaffected by the change in frequency and it is higher than 99% at any frequency. The frequency has an opposite effect on the grade of middle and bottom layers. The ABS grade of middle layers is increased with decreasing frequency, whereas the PET grade of bottom layers is decreased. As a result, the highest ABS grade of 99.7% is obtained at frequency; 10 cycles /min and the highest PET grade of 99.2% at frequency; 40 cycles/min.

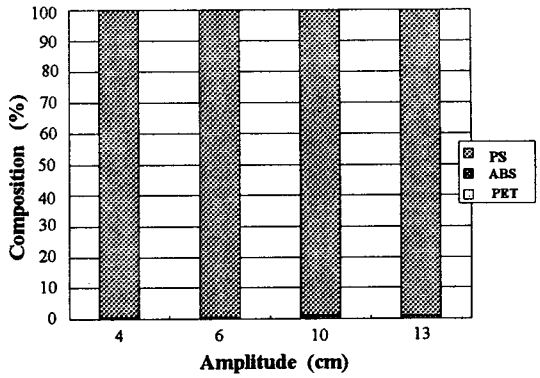


Fig. 6 Effect of pulsation amplitude on PS grade of upper layers at frequency; 40 cycles/min, bed thickness; 6 cm and total pulsation number; 50.

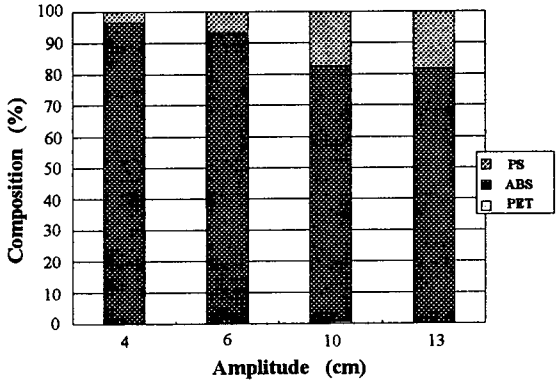


Fig. 7 Effect of pulsation amplitude on ABS grade of middle layers at frequency; 40 cycles/min, bed thickness; 6 cm and total pulsation number; 50.

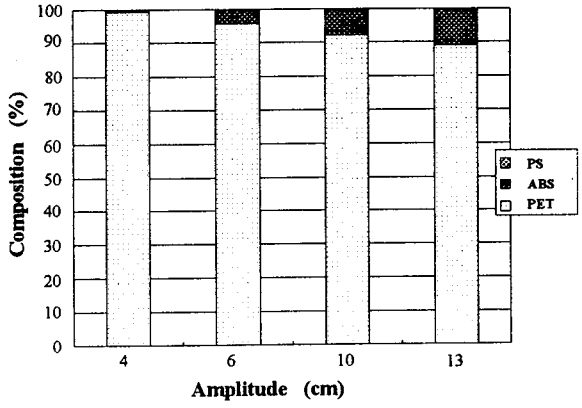


Fig. 8 Effect of pulsation amplitude on PET grade of bottom layers at frequency; 40 cycles/min, bed thickness; 6 cm and total pulsation number; 50.

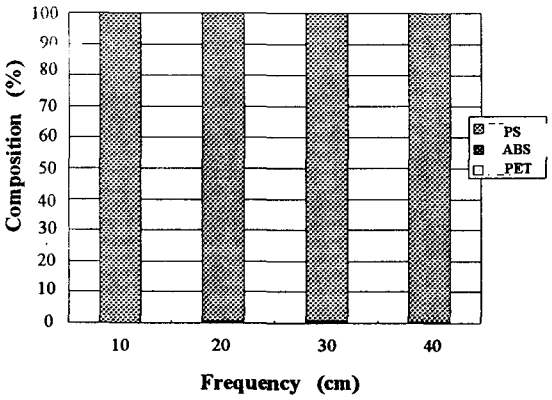


Fig. 9 Effect of pulsation frequency on PS grade of upper layers at amplitude; 4 cm, bed thickness; 6 cm and total pulsation number; 50.

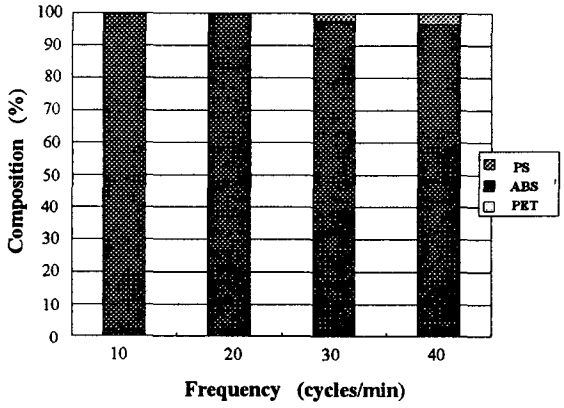


Fig. 10 Effect of pulsation frequency on ABS grade of middle layers at amplitude; 4 cm, bed thickness; 6 cm and total pulsation number; 50.

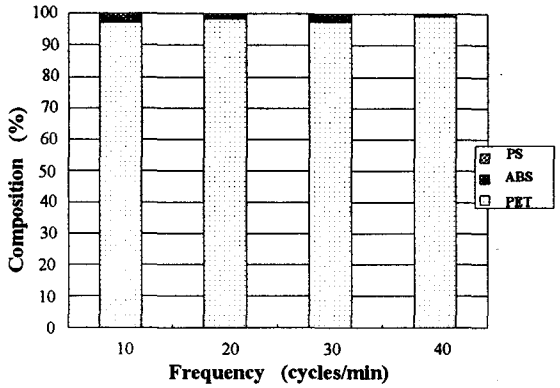


Fig. 11 Effect of pulsation frequency on PET grade of bottom layers at amplitude; 4 cm, bed thickness; 6 cm and total pulsation number; 50.

Under pulsation conditions able to dilate the bed, the PS grade of upper layer is not influenced by amplitude and frequency. However, the ABS grade of middle layer and PET grade of bottom layer are affected by them. A jig operation condition is determined depending upon the purpose of the jig separation in a plant. As shown in Table 1, three products of high grade can be obtained under optimum conditions (amplitude; 10 cm, frequency; 10 cycles/min, bed thickness; 6 cm, water level; 8cm and total pulsation number; 100).

Table 1 Grades (%) of products obtained under optimum conditions

| | PS | ABS | PET |
|---|---|---|---|
| Upper Layer | 99.8 | 0.2 | 0 |
| Middle Layer | 0.7 | 99.3 | 0 |
| Bottom Layer | 0 | 1.4 | 98.6 |

*Outline of Processing Plant for Recycling of Plastics From Scrapped Copy Machines*

As mentioned above, jig technology is an effective method for separation of plastics used in copy machines. The authors are now constructing a processing plant for recycling of plastics based on the present results. The processed materials are mainly scrapped copy machines from that printed wiring boards, photosensitive drum are hand-picked, and then fed. Figure 12 shows the outline of the processing plant which will be completed by March, 2002. The details of the plant design will be reported in near future.

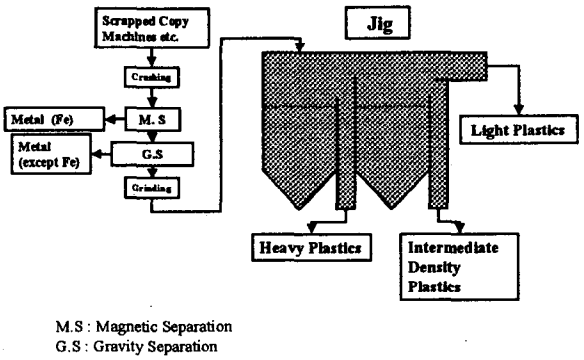


Fig. 12 Outline of processing plant for recycling of plastics from scrapped copy machines.

## Conclusion

In the present study, mechanical separation experiments on plastics [polystyrene (PS), acrylonitrile butadiene styrene (ABS), and polyethylene terephthalate (PET)] used in copy machines were carried out using a TACUB jig. The effects of water pulsation including amplitude and frequency on the separation performance were investigated for the feeds containing two or three plastics. These results indicate that jig technology is an effective method for separation of plastics used in copy machines. Good results are obtained under suitable conditions and grades of 99.8% PS, 99.3% ABS, and 98.6 % PET are recovered as the products in the upper, middle and bottom layers respectively. A processing plant for recycling of plastics from scrapped copy machines is now under construction based on the present results.

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