Effect of particle size and density in flotation deinking of electrostatic papers

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ABSTRACT: The particular type of electrostatic printing machine affects the flotation deinking behavior of pulps from this source. Slower–printing machines produce larger toner particles which contain attached fibers after pulping. These fibers greatly retard effective flotation. Producing the smallest toner particles provides the greatest separation of toner and fiber. This is the primary step for optimization of repulping to provide the best separation of toner and fiber.

KEYWORDS: Deinking, density, electrostatic copying papers, flotation, ink, particle size, printing machines, toners, waste papers.

The increasing presence of electrostatically printed papers in the recovered paper streams has spawned efforts to deink these papers effectively. The high-quality fiber available from this source is particularly desirable, when it is clean.

Although flotation is a major method of deinking, it is often ineffective for these papers. Our investigations showed that the particular type of electrostatic printing machine affected the flotation deinking behavior. This reinforces earlier work which showed that the type of electrostatic printing device influenced the deinking results *(1)*. It supplements other work indicating that flotation has difficulty removing large toner particles *(2)*.

Materials and methods

We performed our experiments on printed sheets from eight machines. Three of these were slower–printing or low-capacity units, and five were faster–printing or high-capacity units. The slower–printing machines were a Heathtek Laser Writer, an Apple Laser Writer, and a Canon NP-115 Copier. The faster–printing machines were a Pitney Bowes 750A, a Sharp 8570, a Xerox 5042, a Xerox 5065, and a Xerox 1090. Each sheet from all the machines had a standard, printed pattern. We mixed 13 g of paper with 2 L deionized water containing 2% by weight sodium hydroxide based on fiber and 10 mg of a commercially available nonionic surfactant, octylphenyl polyethoxylate with n value (average number of ethoxylate groups) of 9–10. This yielded a consistency of 0.65% and a pH of 12.

We next disintegrated the mixture for 75,000 cycles at 24°C in a commercial disintegrator. We made a single handsheet using the entire slurry after repulping. This was the control.

We then performed three flotation runs for each type of machine. For the first case, we followed the above procedure except that after repulping we floated the slurry in a commercial 2.5-L flotation cell for 2 min at room temperature. Then we made a single handsheet from the entire slurry. We added additional water as necessary to maintain the liquid level in the flotation cell. For the second and third cases, we added either 10 mg hexadecyltrimethylammonium bromide (HTAB) or 10 mg sodium dodecyl sulfate (SDS) in addition to the original nonionic surfactant before following the flotation procedure.

We analyzed the 16-cm handsheets for dirt area and toner particle size by image analysis using a picture area 3 cm across for a view area of 7.75 cm^2. We then randomly selected four such areas on each side of the handsheet for analysis. The image analysis settings remained

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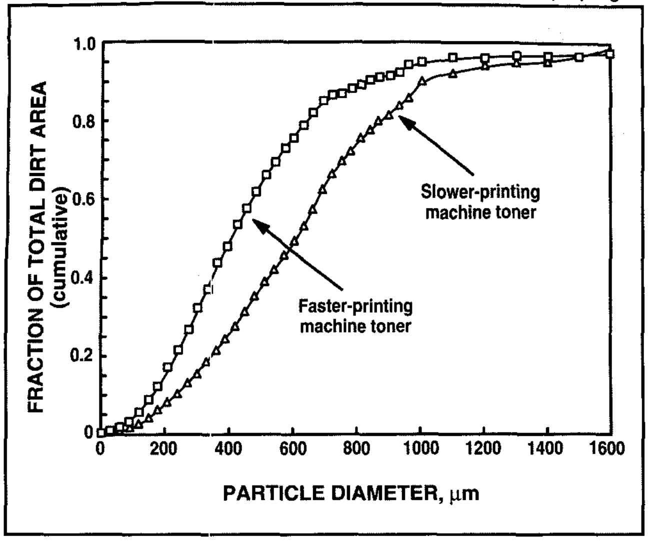
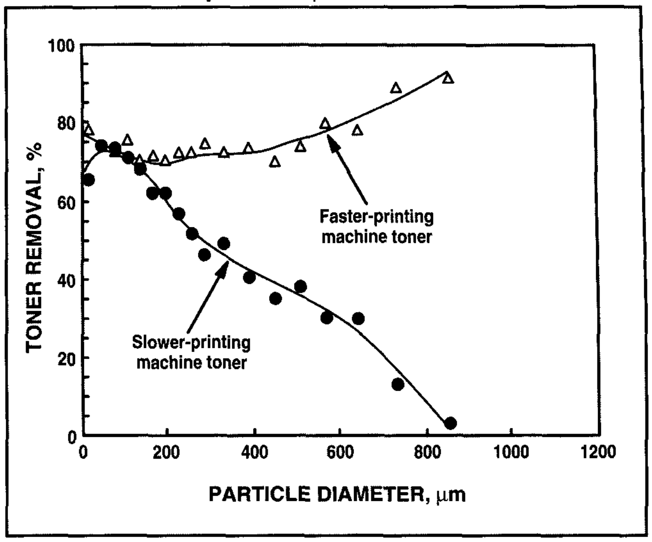
1. Representative toner particle size distributions after repulping



2. Flotation efficiency vs. toner particle size



constant for all the runs to ensure comparability of results. The resulting data contained a listing of all the particle areas. From this, it was easy to construct a size distribution to determine the fraction of dirt area attributed to given particle sizes. Comparison of handsheets from flotation runs with the control handsheet for each type of printing machine allowed calculation of the percentage of toner removal for each run. This is a measure of overall flotation efficiency and is a function of toner particle size.

We measured toner densities using a commercial pycnometer.

Results and discussion

Classifying the copiers and laser printers according to the speed of print output reveals a great difference in deinking. The five faster–printing copiers produce printed sheets that deink with 89% average toner removal. The three slower–printing laser printers and copiers produce printed sheets that deink with 55% average toner removal *(3)*. For the three flotation cases for each machine, we found that the differences in toner removal among the cases were small compared to the differences in toner removal among machines. We therefore combined the results of the three flotation cases to obtain an average flotation removal for each machine.

Considering each particle size, apparently the faster–printing machines produce smaller average particle sizes on repulping at low consistency. **Figure 1** indicates this by showing the toner particle size distributions after repulping for a representative slower–printing machine toner and a faster–printing machine toner. While 50% of the dirt area determined by image analysis comes from particle sizes larger than 400 µm for the faster–printing machine, 75% of the dirt area comes from particle sizes larger than 400 µm for the slower–printing machine.

What is even more striking is the indication from **Fig. 2** that the two types of machines show different behavior when comparing the flotation effectiveness to the toner particle size. In this case, toners from the faster–printing machines effectively float at all particle sizes. Removal of the larger particles is more effective than for the smaller particles. The removal of the toner particles from the slower–printing machines contrasts with this, however. These toners remove well at the smallest particle sizes of less than 100 µm, but the removal efficiency decreases steadily with increasing particle size. It approaches nearly zero for particles 1000 µm or 1 mm in diameter. The poorer flotation removal of the toners from the slower–printing machines is therefore primarily due to the particles larger than 100 µm.

In considering why the trends of removal efficiency with particle size were so different for the two types of machines, we noted that the slower–printing toners are more dense and magnetic. Because of the magnetite, Fe_3O_4, present at 10–30% by weight, the densities of these toners average 1.5 ± 0.04 g/mL. The toners from the faster–printing machines average 1.2 ± 0.07 g/mL by contrast. The denser particles may not effectively attach to the bubbles during flotation. More likely, however, the denser particles are less likely to remain attached to the bubbles in the turbulent flotation cell. A maximum size for particles to float effectively is a well known phenomenon in mineral flotation. Models indicate that the maximum particle size depends on density *(4)*.

Careful examination of the printed sheets from the two types of machines suggests another explanation. The slower–printing machines produce printing that appears to be darker and thicker. This may be a natural consequence of the longer time the sheets spend in the printing process. In particular, the slow passage through the hot roller section of the printing device may promote deeper fusing of the toners to the paper fibers by mechanical entanglement.

The slower–printing machines therefore produce larger toner particles which contain attached fibers after pulping.

Larger particles are more apt to contain fibers. Such fibers greatly retard effective flotation for two reasons:

- The fibers are hydrophilic and have no driving force to attach to the bubbles.
- When the conglomerates of toner and fiber attach to the bubbles, the fibers increase the exposure of the particle to the turbulent forces present in the flotation cell. This increases the rate of particle detachment and reduces the chance to carry the particle into the froth layer.

Other workers have provided strong evidence for the second explanation of poor floatability *(5)*. Their examination of toner particles fed into a flotation cell found that 58% contained attached fibers. The flotation rejects contained only 10% and the accepts contained 68% attached fibers. These investigators also found that virtually all the large particles above 500 μm fed to the flotation cell contained attached fibers. Only 76% of the medium sized particles of 200–500 μm and only 30% of the small particles below 200 μm contained any attached fibers.

Both explanations of the trends of poor flotation efficiency of the large toner particles from the slower–printing machines indicate that these particles easily detach from the bubbles in the flotation cell. Both mechanisms may operate together. In any case, the causes for the observed trends of the slower–printing machines are not present to any significant degree for the faster–printing machines.

Conclusions

The results of this work provide three suggestions:

- Sheets from slower–printing machines probably cause difficulties in flotation deinking of the electrostatic inks.
- The larger particle sizes from slower–printing machines are the most troublesome.
- The key step to optimize repulping for the successful flotation of electrostatic inks is to produce the smallest toner particles. This will provide the greatest separation of toner and fiber. TJ

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The authors gratefully appreciate the financial support from the Forest Products Laboratory, Madison, WI, and from the Fisken Fellowship of the Weyerhaeuser Foundation.

Received for review Sept. 3, 1993.

Accepted Oct. 23, 1993.