Recent innovations in paper recycling

Peter Seifert

ABSTRACT: From many process steps in paper recycling systems, two have been selected for discussion, namely washing deinking and flotation deinking. Recent innovations are reviewed, in the context of the basic mechanisms responsible for the functioning of these machines. An update is also given for their application in the processing of used office papers.

KEYWORDS: Concentrators, deinking, flotation, flotation machines, recycling, separators, solid wastes, washers, washing, waste papers.

Increased paper recycling is on many people's minds and has become an accepted reality. Significant capacity increases have been realized in recycling of old corrugated containers for brown grades, mixed waste recycling for multi-ply boards, and old newsprint reprocessing to make new newsprint.

A new technological challenge lies in utilizing used office paper and upgrading it, by deinking, to tissue or even printing grades. Even in this field, substantial tonnage already is being processed, but with significant presorting required.

In this paper, I do not want to rehash the entire deinking process philosophy and practice but, rather, concentrate on a discussion of some significant, individual process steps. My selection includes ink removal by washing and by flotation. I plan to show how these machines function and which parameters are truly important to obtain maximum benefit. The user then can make better decisions on which equipment to employ or how to better use machinery that he or she already has.

My company also is actively participating in the evaluation and optimization of other new processes such as Recoupe steam explosion, oxygen bleaching of recovered paper, and agglomeration technology for Xerox and laser-containing recovered papers. In addition, we are developing new pulping technology and continuously work on improving cleaners for light and heavy dirt removal. These processes will be discussed at other times; space simply does not allow me to cover all the new technology here. Mere mention of them should help you to put into proper perspective the topics covered in this paper.

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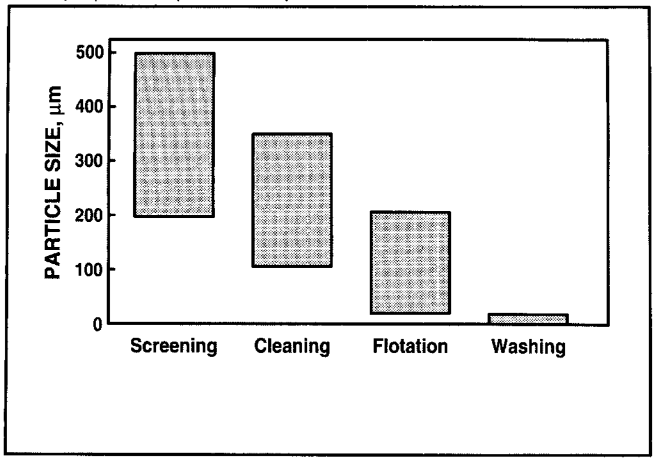
Washing

Ink removal systems have two hearts: flotation and washing. They commonly deal with ink particles in different size categories, as illustrated in **Fig. 1**. Washing is effective for very small particles (10–20 microns) and below, which is a size not visible to the naked eye. Flotation addresses the next larger group of particles and, subsequently, so do cleaning and finally screening.

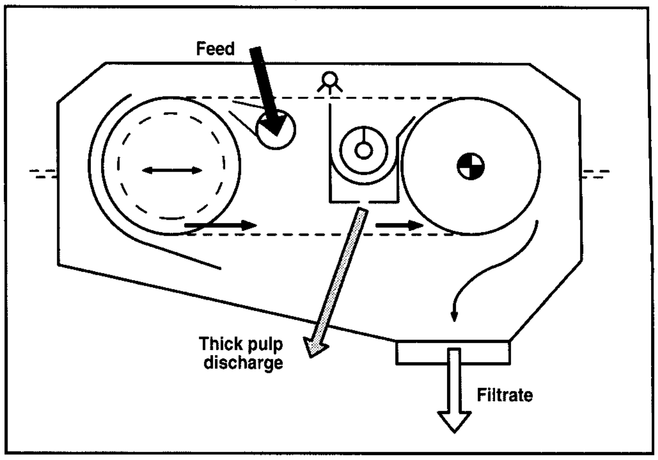
Washing to remove small particular contaminants from recovered paper goes back to the 1950s and 1960s, where the literature describes use of deckers *(1)*, side hill screens *(2)*, paper-machine-type washers *(3)*, and screw thickeners *(4)*. Today, a tissue-machine-style washer by Sulzer Escher Wyss is in use *(5)* and a new device by Black Clawson—the DNT washer *(6–8)*. This latter unit (**Fig. 2**) is certainly not a paper-machine-style washer. It consists of an endless wire mesh loop, which travels at high speed around only two rolls; the slurry is injected and stays on the inside surface of this loop. A sheet is not formed because the first roll has deep grooves, causing pulp to thicken in the form of strips. These strips stay on the wire mesh, go around the second roll, separate from the wire to follow the roll surface, and are doctored off for discharge. There is no way that a sheet of paper is formed in this machine, and, even if it were, it could not be guided out of the loop.

The great advantage of such a two-stage washer lies in the very high percentage of feed water that is rapidly removed and the small proportion that

1. Efficient removal of contaminants by particle size and conventional stock preparation process steps



2. Schematic of the Black Clawson DNT washer with pulp mat on inside surface of wire mesh loop



stays with the pulp. The discharge consistency ranges from 10% to 14%. Another factor responsible for the high washing efficiency is that the pulp strips are very thin.

One measure of washing efficiency is the brightness gain of the pulp as small, invisible ink and dirt particles are removed; these particles normally would render the pulp gray. Naturally, some cellulose fines also are washed out, and often we try to minimize that loss. **Figure** 3 shows an example of ink removal from a pulp furnish containing flexo printed newsprint and magazine paper, a mix that does not respond well to deink flotation. Different deinking methods are used. Clearly, the DNT washer has the best brightness gain and also the best balance of brightness gain versus yield.

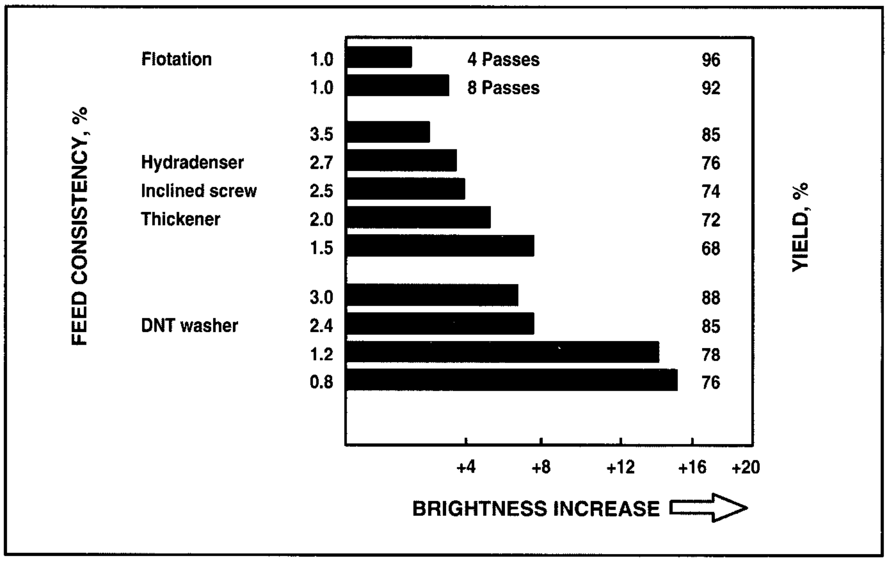
Similarly, ash—i.e., inorganic fillers, clay, and coating particles—is removed, another measure of washing efficiency. **Figure** 4 shows an example of such results in a ledger processing tissue system.

Just about 100 DNT washers are now operating.

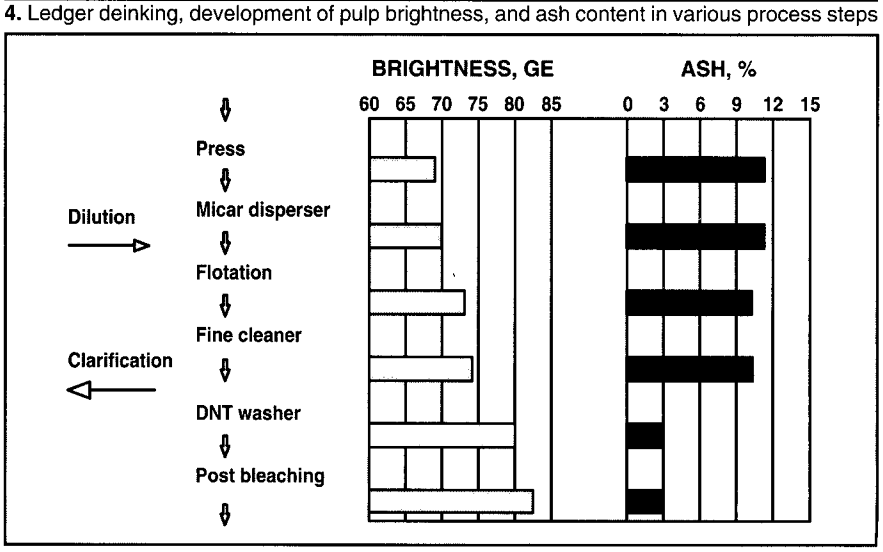
Flotation

Ink removal by flotation also started in the 1950s when this technology was transferred to paper recycling from the mining industry. Since then, many solutions have been found to blow air bubbles into the pulp slurry to catch

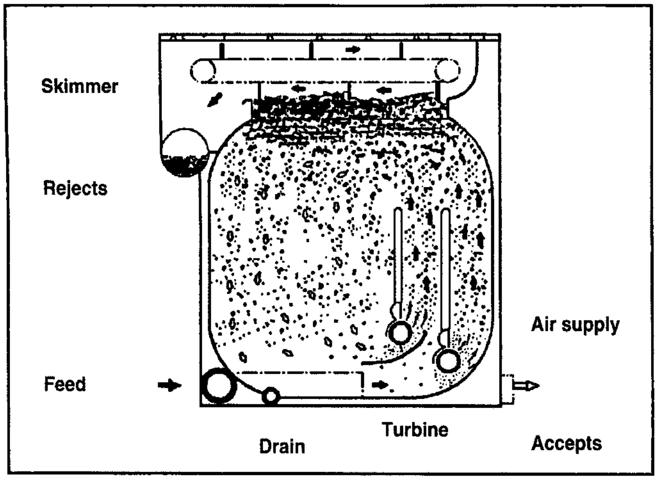
3. Effect of different deinking treatments on brightness using a mix of 70% flexo printed newsprint and 30% magazine paper. Starting brightness is 39 GE.



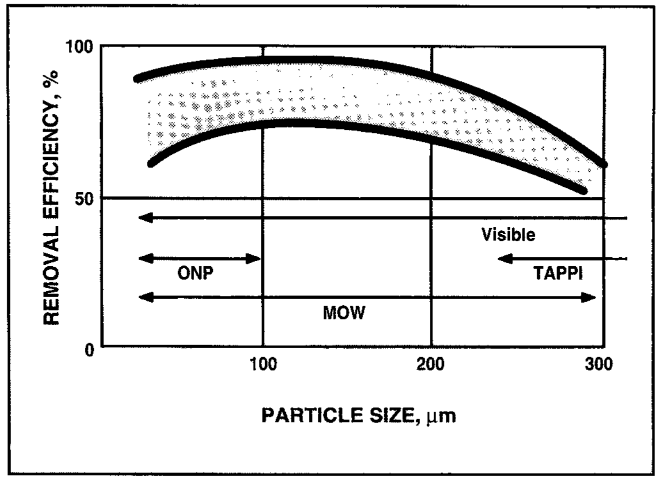
4. Ledger deinking, development of pulp brightness, and ash content in various process steps



5. Schematic of the Black Clawson/IIM flotator featuring very high rates of air introduction



6. Typical efficiency of flotator treatment for removal of contaminant particles by size for various applications



the hydrophobic ink particles (sometimes also stickies and clay) and carry them to the surface for removal as foam *(9)*.

Obviously, the more air introduced, the greater the ink removal, but there is a problem, namely turbulence and subsequent remixing of the ink contaminants. The common solution to the problem is to use very little air (20% volumetrically per stage, based on flow rate) and repeat the treatment in successive stages. Sometimes as many as six stages are used, rendering air addition of 120% based on flow rate *(10, 11)*. Reference 10 includes an example for multistage treatment, an early design by my company, with cells stacked on top of each another. The concept recently has been revisited by others.

Now we have licensed a new and different flotation cell developed in Japan. This design *(12)* has overcome the old barriers and operates with only one large stage; it permits addition of huge quantities of air, 6–10 times the volumetric pulp flow rate (600–1000%), without detrimental levels of turbulence. **Figure 5** is a picture of the cell showing inlet and outlets for slurry, air manifold and mixers, and the foam discharge.

The new flotator cell is operating commercially, treating a mix of news and magazine recovered paper in Japan and in North America. The brightness gain is on the order of 10–14 points GE, very high by any standard *(13)*. In another installation, the cell processes 100% old newsprint (not flexo printed), achieving a brightness gain of 8 points GE, almost double conventional cell performance *(13)*. The latter normally requires the presence of magazine papers to achieve acceptable brightness gains.

More recently, a unit also has started on ledger-to-tissue deinking with similarly good results, which are included in **Fig. 6**.

When we brought a mobile pilot flotation unit into a paper mill, it was connected to treat the rejects from a primary conventional flotation cell. No further chemicals were added. Surprisingly, the fibers recovered from the new flotator had a higher brightness than the accepts of the conventional primary cell in operation in the mill. We attribute the overall good performance of this new flotation cell to the unique combination of high quantities of air, good mixing of the air, and suppression of detrimental turbulence.

Deinking of office waste

The deinking of office waste represents an additional challenge, namely the removal of small but visible particles of ink from xerographic and laser printed recovered papers. Apparently, these particles are sufficiently strong to survive the turbulence in pulpers, pumps, and dispersers and remain in the pulp as very unsightly contaminants, not unlike spots of pepper.

Combinations of flotation and washing with other steps like centrifugal cleaning and dispersion are still the current commercial solution to this problem, and the selection of high-efficiency unit operations contributes to overall better success. Still, such dirt removal is a "percentage matter," and as incoming waste varies in content and type of xerographic and laser printed materials, results also can vary.

For this reason, we are active in the evaluation of other processes like Recoupe steam explosion *(14)* and ink agglomeration technology *(15)*. The former relies on thickening pulp and then heating it for a short time under steam pressure to about 200°C in a continuously operating pressure vessel. Discharge through a blow valve causes rapid flashing of the hot water ("explosion") and a high dispersion effect, which reduces the heat softened contaminants to very small size and makes them removable by washing. In cooperation with Recoupe Technologies, Inc., we hope to offer this process to treat wastes that cannot be processed successfully and economically by conventional means.

One completely different avenue is not to disperse but to agglomerate ink particles into fewer larger ones. These larger particles may be removed by screening, flotation, or fine centrifugal cleaning. We are actively providing process equipment and conducting pilot studies to test this technology.

Conclusions

Deinking is an important function in the recycling of a new raw material—office waste. Fine ink particles must be removed to raise the brightness, and larger visible ink particles from xerographic and laser printed waste require removal to improve appearance.

A new two-stage washer was discussed and examples of its performance shown in terms of brightness gain and ash removal. Effectiveness of the washer must always be compared with overall yield, and examples of this also were given.

Single-stage flotation with introduction of high quantities of air also has become a very effective tool for raising pulp brightness and for removing ink particles in the visible range. Several commercial and pilot results have been discussed that have air addition rates of 600–1000% in a single stage and produce exceptional results.

Office waste contains Xerox and laser-printed papers which often produce unsightly pepper-like spots in the deinked pulp. This problem is addressed with combinations of flotation, dispersion, fine cleaning, and washing. Still, we are trying to further improve final quality by evaluating new technologies such the Recoupe steam explosion and the agglomeration technology.

Ink removal is a very important part of recycling of secondary fiber for reuse in printing papers, and our company is proud to offer contributions at the forefront of paper recycling development.

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Developments and insights such as the ones reported here are the result of work by our entire technical development and marketing teams and significant contributions by other companies with whom we cooperate, such as IIM of Japan, Recoupe, Betz, and others. This fact should hereby be recognized, acknowledged, and stressed beyond a mere mention in the references.

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