Deinking of Thermal Inkjet Newsprint

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Abstract

The advantages of digital printing are emerging into commercial printing. Deinking of inkjet prints is important because they will become a sizable portion of the waste stream. Thermal inkjet ink dispersions are water-based and under certain chemical environments can remain suspended in the process water during flotation, potentially causing discoloration in a closed-loop water system during deinking [1]. Newsprint has not been a major inkjet printing category for digital commercial inkjet prints but the recycling industry has expressed concern about the deinkability of this combination. Also, while newsprint is rarely used in the office, the advent of the commercial inkjet web press will see increasing interest in the recyclability of inkjet on newsprint media, since it provides the option for deployment of newsprint media for short-life (non-archival) printing. When inkjet inks are printed on newsprint, made from wood-containing pulp with lignin, which is then included in the papermaking furnish, the problem of process water darkening can be exacerbated under some chemical conditions. Ideally, the individual sub-micron pigments and molecular dyes in inkjet ink dispersions should be collected to form larger particles of the appropriate size and also made hydrophobic for efficient flotation.

In this paper, we show that inkjet-printed newsprint can be satisfactorily deinked via chemistry based on our near-neutral HPES deinking chemistry, described previously [2]. Two kinds of chemicals are used; the "E" in HPES is ethoxylated fatty alcohol, which interacts with the ink and fibers, separates them and prevents the ink from reattaching, while aggregating small ink particles into larger ones. The "S" in HPES is a small amount of an ionic surfactant added into the flotation cell, which facilitates the creation of bubbles which carry particles to the top where they can be skimmed off with the froth, leaving the clean pulp fibers to be recovered. We studied the effect of pH, collecting and clarifying agents, water hardness, chemical loading, and bleaching chemistry on filtrate darkening. In particular, we have found that the color shade and brightness of the deinked pulp and the process water can be significantly enhanced with the addition of a suitable collector or flocculating agent, in this case aluminum sulfate.

Introduction

A simple view of inkjet particles is that they are very small, sub-micron in diameter, and are hydrophobic. While this is true in liquid ink, when the ink is printed and dries on paper its properties change; the particles agglomerate and may become hydrophobic. The ink interacts with the media and is affected by the surface morphology and chemistry of the media and any fixers or coatings. Ideally, the individual sub-micron pigments and molecular dyes in inkjet ink dispersions should be collected to form larger particles of the appropriate size, and also be hydrophobic, for efficient flotation [3]. Lab-scale pulping and flotation experiments at Hewlett-Packard Laboratories have been conducted to understand and optimize deinkability for inkjet inks and media including newsprint. In order to demonstrate deinking efficiency for HP digital inkjet inks on newsprint media, develop cost-effective pragmatic deinking solutions, understand the nature of deinking and our inks, and help inform future ink and media development.

Newsprint is a low-cost, light weight, short-life (non-archival) high strength paper [4]. It is typically used for newspapers and flyers, and is designed for and enabled by web-based printing. It is mostly made from thermo-mechanical pulp (TMP) and recycled paper. The pigmented ink mostly sits on top of the newsprint and releases well from the paper. However, since the newsprint is only lightly coated or uncoated, and has few fillers or sizing, particle agglomeration is sometimes not facilitated and the small pigment particles can remain in solution rather than being removed during flotation.

Experimental

Tests were performed on site at our deinking laboratory. Trial tests were performed on a generic newsprint media from Pacon to optimize the chemical dosing including the aluminum sulfate and the foam production. Then seven test newsprint samples were used, as listed in Table 1. All were printed using an HP thermal inkjet printer with black pigmented ink using the INGEDE black test pattern.

Table I. Paper Media Samples

	Grade	Furnish	Acidity	Coating
T1	Newsprint	100% TMP	7.3	light
T2	Hybrid	50% TMP / 50% Kraft	5	light
T3	Coated	50% TMP / 50% Kraft	5	yes
T4	Super calender	100% TMP	5	no
T5	Newsprint	100% TMP	5	no
T6	Newsprint	100% Recycled	6	no
T7	Newsprint	80% TMP / 20% Recycled	6.3	no

The pulping chemicals were mixed with warm deionized water (~ 45°C) treated with calcium chloride to achieve a water hardness of 128 mg Ca^{2+}/L to achieve a consistency (solid content by weight) of 15%. A Hobart N50 mixer was used for 20 minutes to pulp the printed test media.

Before the flotation stage, the stock was further diluted with 45°C warm process water to a consistency of 0.8% in the Voith Delta25 flotation cell. Air flow and agitation from the rotor in the bottom of the cell cause bubbles to rise within the cell.

Hydrophobic ink particles and other fines from the paper or paper coating attach to the bubbles and float to the top where they form a froth, which is skimmed off. Flotation proceeded for 12 minutes, with extra warm water added during the process to ensure overflow.

The dosing of the chemicals is shown in Table 2.

Table 2. Chemical Dosing

Chemical	Dosage (related to oven-dry paper)
Pulping:	
MYRJ45	0.6 %
Flotation:	
SDS	0.2 %
$Al_2(SO_4)_3$	0.5%
H_2O_2	0.7 %
$Na_2S_2O_4$	0.7 %

Filter pads and handsheets were formed before and after flotation to provide accurate color and reflectance measurements to determine the ink elimination, assessed using standard benchmarking techniques.

Optical measurements of handsheets and filter pads were performed using an Elrepho spectrophotometer. Deinking was evaluated using the European Recycling Paper Council (ERPC) deinking scorecard [4]. While the European Recycling Paper Council (ERPC) scorecard is tied to the INGEDE Method 11 [5], the Deinkability Score including Ink Elimination and Filtrate Darkening scores are calculated as a useful reference. Individual scores summing up to 100 points were calculated for luminosity (L), color shade (a*), dirt particle area (A), ink elimination (IE) and process water darkening (ΔY). Target and threshold values are specified, and if any result is outside of the threshold the product is rated "not suitable for deinking. A score above 70 is considered to show "Good Deinkability".

Results and Discussion

We found that adding aluminum sulfate during flotation allowed the pigment to agglomerate and form larger particles of 1 to 3 µm diameter. These large particles have a higher probability of interacting and sticking to the bubble surface during flotation so that the ink is removed.

Process water was removed during flotation and the particle size of the suspended ink was measured using dynamic light scattering (DLS). We found that adding more aluminum sulfate to the process water, increasing the acidity, caused the particles to further agglomerate. For good deinkability we found the minimum amount of aluminum sulfate to achieve a slight agglomeration but not complete flocculation to be 0.5%

Figure 1 shows the Ink Elimination scores for the seven samples. Samples were collected and evaluated during the flotation process at 4, 8 and 12 minutes flotation time. In general the ink elimination improves with longer flotation time.

The Filtrate Darkening results for the seven newsprint samples are shown in Figure 2 Filtrate Darkening results for the seven test newsprints. Here long flotation times are not necessary to achieve absence of filtrate darkening. Five of the samples were under the threshold for acceptible filtrate darkening.

All five of the scores are added for a Total Deinkabiltiy Score shown in Figure 3. Here the criteria are that none of the scores can have a negative value and the sum of the scores must be above 70 to show "good deinkability".

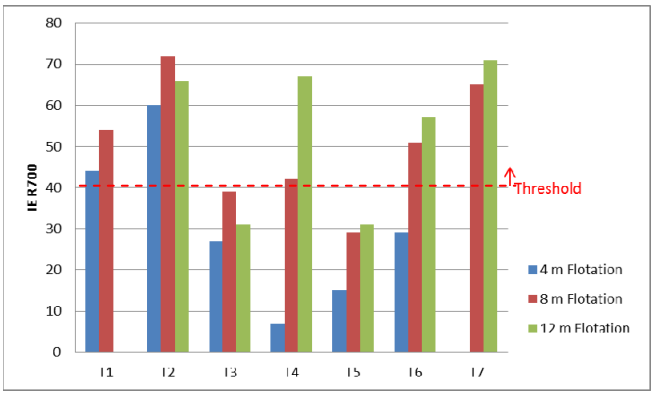

Figure 1. Ink Elimination, based on reflectivity at 700 nm, vs. flotation time for all newsprint samples. The minimum threshold for this score is 40 for newsprint, and five of seven samples had sufficient Ink Elimination.

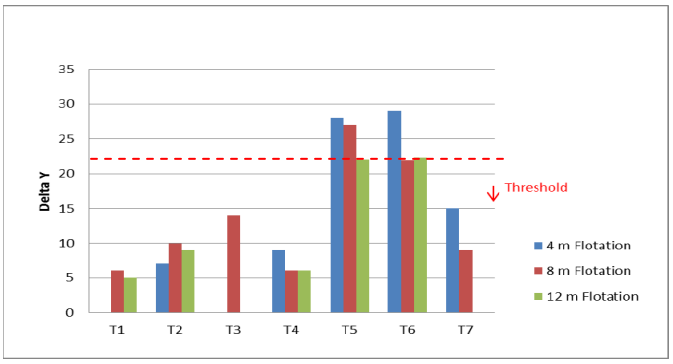

***Figure 2**. Filtrate Darkening, ΔY, vs. flotation time for all newsprint samples. The Darkening is minimized so that it is less than the threshold. Five of seven samples met this criterion.*

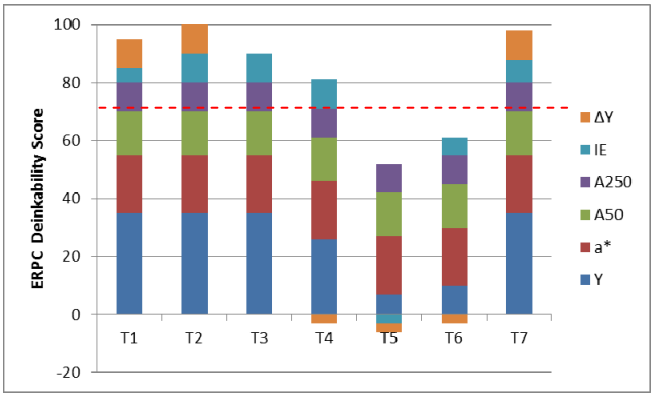

***Figure 3**. Total Deinkability Score for all newsprint samples. ΔY is filtrate darkening, IE is Ink Elimination, A250 is speck count of particles above 250 µm diameter, A50 is speck count of particles above 50 µm diameter, a* is the red-green color shade, and Y is luminosity.*

Conclusion

Good deinkability can be achieved for a selected range of inkjet-newsprint combinations using HPES chemistry at lab scale. The deinkability is strongly influenced by the paper composition. The critical parameters for ink jet deinkability are filtrate darkening and ink elimination show improvement when aluminum sulfate is added to the HPES chemistry. Aluminum sulfate is an effective collector to improve deinkability of inkjet prints on newsprint.

Acknowlegements

The authors would like to thank their colleagues Minedys Macias and Gregg Lane for paper samples and valuable input.

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