COMPARISON OF DIP BLEACHABILITY BETWEEN TRADITIONAL SOAP AND REDUCED ALKALINE CHEMISTRIES

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ABSTRACT

Reduced alkaline deinking is of interest to many mills. Reduced alkaline pulper chemistry can supply similar ink contents in the final pulp as can be obtained using traditional alkaline deinking. This study follows the development of brightness and residual ink through a pilot deinking process including a post bleaching stage. These results are obtained for pulps deinked using both traditional alkaline fatty acid chemistry and for pulps using a new reduced alkaline synthetic blend chemistry.

The brightness obtained on flotation accepts for the traditional alkaline fatty acid chemistry, which contained peroxide in the pulping process, was higher than the brightness obtained using the reduced alkaline chemistry which did not have peroxide present in the pulping. Interestingly, the results reveal that following post bleaching the two pulps had the same residual ink and brightness. In other words, the reduced alkali pulp was more responsive to the post bleaching chemicals than was the pulp processed under traditional alkaline deinking conditions.

INTRODUCTION

The pursuit of continuous improvement in quality, environmental safety, and profitability has resulted in an increased interest in new deinking scenarios. One scenario of interest is the production of deinked pulp from old news papers (ONP) and old magazines (OMG) in systems that eliminate or reduce the use of sodium hydroxide in the repulping process.

Removing sodium hydroxide from the pulper can reduce alkaline yellowing. Subsequently, if alkaline yellowing is not an issue, then the use of hydrogen peroxide may also be eliminated in the repulper. Hydrogen peroxide has no direct effect on the detachment of difficulty attached ink such as aged offset ink printed on newspaper [1] except for the possibility to break cross-linked alkyl binders in the ink [2].

Neutral deinking and other alternatives to traditional deinking have been the subject of an increasing number of research papers. Generally, the benefits of neutral deinking are lower total chemical costs, lower COD release and ability to remove alkaline sensitive printing inks, like flexo, and improved stickies control [3,4,5,6,7,8,9]. The lack of ink release, increased ink fragmentation, yield, and reduced ink removal efficiency are some of the barriers that have to be overcome [1,5,10].

Hornfeck et al. concluded that only coated magazine grades can be efficiently deinked in neutral conditions in the presence of appropriate surfactants [11]. Galland et al. stated that an alkaline stage appears to be absolutely necessary for deinking mixtures containing offset printed papers such as aged print on uncoated paper [10]. Two flotation deinking loops are necessary because the easy-to-detach and water-based inks are removed during the first neutral loop whereas the hard-to-detach offset inks are detached during the “alkaline bleaching/kneading” treatment and removed during the second alkaline flotation loop [1, 10, 12]. Rosencrance et al. (2005) have, however, reported that several mills are in fact using true neutral deinking chemistry and obtaining similar results as in alkaline deinking of ONP/OMG mixtures [13].

Sulphite deinking in neutral and near-neutral conditions have additionally been extensively studied in laboratory and also in mill scale. In sodium sulphite deinking, sodium sulphite replaces sodium hydroxide, hydrogen peroxide and silicate in the pulper. [3, 14, 15, 16, 17, 18] During a short mill trial it was observed that sulphite
deinked pulp responded better to sodium hydrosulphite in a post-bleaching than the pulp deinked at conventional alkaline conditions [16]. Incompatible results were, nevertheless, reported after a longer mill trial [3].

Schwinger and Bast-Kemmerer concluded that neutral deinking needs a post-bleaching stage to meet the high brightness targets [19, 20]. Dingman et al. found that the post-bleaching response of the caustic free (neutral) deinked pulp and alkaline deinked pulp is the same in bleaching [21]. Poor bleaching response of neutral deinked pulp caused by the ineffective ink removal was reported by Süß et al [22].

The response of the bleaching can vary depending where it is performed. Bleaching after flotation is believed to be more effective than bleaching before flotation because of the reduced amount of disturbing substances in the pre-treated suspension [23]. Results favouring the pulper bleaching compared to post-bleaching have also been published [24].

Even if neutral and low alkaline deinking is intensively researched, the interdependence of deinking chemistry and bleaching response is an area requiring further exploration. The aim of this study was to evaluate the bleaching performance for pulps produced via both a reduced alkaline chemistry and a traditional alkaline chemistry. The studies were performed using a pilot scale equipment to produce pulp which was then post-bleached in the laboratory.

MATERIALS AND METHODS

Papers

The recovered paper used was pre-consumer grade received from Germany. The paper was aged for 18 weeks at 15-20°C and 34-50% humidity. The average ash content of the paper is presented in Figure 1. The furnish composition used in this study consisted of 50% of newspapers (ONP) and 50% of magazine (OMG) grades. The OMG paper was 50% SC (super calandered) and 50% LWC (light weight coated).

![Figure 1. Average ash content of recovered paper](image)

Deinking chemicals

The evaluations utilized two deinking chemistries as shown in Table 1. These were a traditional alkaline fatty acid program and the Lionsurf reduced alkaline blend chemistry. Prior to pulping, the chemicals were mixed with water in the pulper feed tank with the exception of peroxide which was dosed directly to the pulper at the same time with the dilution water. The dosages of sodium hydroxide and hydrogen peroxide are on a 100%
basis while the dosages of sodium silicate, fatty acid soap, and Lionsurf are on an as received basis. The hardness of the pulper water was adjusted with calcium chloride to 150 ppm for the alkaline fatty acid and to 50 ppm for the reduced alkaline trial.

Table 1. Deinking chemical dosages.

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<th>Deinking chemical dosages, kg/t</th>
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<tr>
<td></td>
<td>Alkaline soap chemistry</td>
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<tr>
<td>Sodium hydroxide</td>
<td>10</td>
</tr>
<tr>
<td>Sodium silicate</td>
<td>10</td>
</tr>
<tr>
<td>Soap</td>
<td>4</td>
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<tr>
<td>Hydrogen peroxide</td>
<td>6</td>
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<tr>
<td>Lionsurf 305</td>
<td>-</td>
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<td>Lionsurf 564</td>
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Bleaching chemicals

Peroxide bleaching was performed on a laboratory scale utilizing accepted pulp from the previous pilot deinking line. The chemical dosages of the peroxide bleaching tests are shown in Table 2. Peroxide bleaching conditions were previously optimised and the optimum dosages were used. The need of alkalinity (sodium hydroxide) is slightly higher after reduced alkaline deinking to achieve optimum peroxide bleaching conditions. The reaction temperature for post-bleaching was 90°C, time 40 min and consistency 10%.

Table 2. Peroxide bleaching chemical dosages

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<th>Bleaching chemical dosages, kg/t</th>
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<tbody>
<tr>
<td></td>
<td>Alkaline soap chemistry</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>20</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>3</td>
</tr>
<tr>
<td>Sodium silicate</td>
<td>10</td>
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In dithionite bleaching the reaction time was 30 min at a temperature of 60°C and a consistency of 4%. A dosage of 8 kg/t of dithionite was used. The pH of the dithionite stage was adjusted with H₂SO₄ to 7.4 before adding the 10% active sodium dithionite solutions. The final pH was 7.0 after bleaching.

Operating procedure

The experiments were performed on a pilot deinking system at the University of Oulu. The system’s primary units are a pulper feed tank, drum pulper, flotation cell, and a wire press. The system also contains a water system in which various levels of mill closure can be simulated. Recovered paper was pulped for 20 minutes at 16% consistency in the pilot scale drum pulper in batches of 33 kg of o.d. pulp. The temperature was 45°C.

After pulping, the pulp was diluted to 2% consistency with equilibrated process water and pumped through a screen basket with perforation of 1.5 mm. Following screening, the consistency was adjusted to 1% in preparation to feed the flotation stage.

The flotation cell is a model of Metso and consists of four sectors. The air flow to flotation was 80 L/min which resulted in an air/stock ratio of 110%. The accepts of flotation were sent to a wire press. After the wire press, the consistency of the pulp was about 20%. This stock was then utilized for laboratory scale bleaching studies.
This post-bleaching stage was carried out in the laboratory in plastic bags. The chemicals were added to the temperature controlled pulp. The pH was measured from the resulting pulp slurry. The bleaching temperature was 90°C for the 10% consistency pulp and the reaction time was 45 min. Filtrate pressed from the pulp slurry was used for residual peroxide titration and the final pH measurement. The carryover of residual peroxide was prevented by dilution and thickening back to 4% consistency prior to dithionite bleaching.

Samples were collected from the flotation feed, flotation accept, wire press outlet, and post-bleaching. For pad preparing, 4 g o.d. pulp was taken and diluted to 1% consistency. The pH of the pulp was adjusted to 7.0-7.5. The pads were made in a Bühner funnel on a paper machine wire and filter paper (Whatman Schleicher&Schuell 589/2). After filtration, the filtrate paper was removed and the pad was placed between blotting papers and pressed with 3 bar pressure for 2 min. The pads were dried in an recirculating air oven at room temperature for at least 12 h. Optical properties were measured the following day.

Brightness, the residual ink value, and colours of the pulp were measured with Lorentzen Wettre Elrepho spectrophotometer. Optical properties were measured four times from both sides of the pad. The average values of the wire side and top side of the pad are presented.

RESULTS AND DISCUSSION

Deinking

The flotation was run so that the mass reject rate was kept essentially constant. The yield over flotation is presented in Table 3. The flotation pH with alkaline and reduced alkaline chemistry was 9.0 and 8.0, respectively.

Table 3. Yield over flotation

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<th>Yield over flotation, %</th>
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<tr>
<td>Alkaline soap chemistry</td>
<td>82.2</td>
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<tr>
<td>Reduced alkaline Lionsurf chemistry</td>
<td>83.1</td>
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In Figure 2, brightness values across the flotation and thickening operations are presented. The hyper washed results are shown in Figure 3. The corresponding figures for residual ink are given in Figure 4 and Figure 5 for flotation accepts and wire press outlet stock.
Figure 2. Brightness development through flotation and thickening.

Figure 3. Hyper washed (HW) brightness after flotation and thickening.

The alkaline soap chemistry gave approximately 4 units higher brightness over flotation than reduced alkaline chemistry. This result is not surprising. It is essential to remember that the alkaline fatty acid chemistry had peroxide presenting the pulper which provides some brightening while the reduced alkaline chemistry had no peroxide present in the pulper and thus there was no possibility for such an increase in brightness.
Kemira’s reduced alkaline chemistry gave equal performance to alkaline soap chemistry when considering the ink removal. The brightness of the reduced alkaline deinking was lower due to the bleaching effect of peroxide in alkaline deinking. Catalase was not detected in pilot process.

The $b^*$-values are shown in Figure 6. The increase of $b^*$ to yellow is mainly caused by the reduction of the ink in flotation and ash removal in the thickening stage as the $b^*$ value evolves in the same way for both chemistries. The furnish contains mainly wood-containing fibres which yellow. Of course, it is important to remember that the alkaline system had peroxide present in the pulper while the reduced alkaline system did not have peroxide present.
According to Schwinger & Schmid, The chemical oxygen demand (COD) in the process waters of the mill depends almost linearly proportional to caustic charge /19/. An equally long trial and the same water consumption gave almost double the Total Organic Carbon (TOC) load for alkaline deinking than reduced alkaline deinking. In the case of alkaline deinking, TOC of the circulation water was 500 mg/L, and less than 300 mg/L in the case of reduced alkaline deinking, respectively.

**Bleaching**

The extent of hydrogen peroxide consumption was followed by measuring the pH drop and titration of the residual peroxide (Table 4). Initial pH of the peroxide stage was 10.0. The final pH was significantly lower on reduced alkaline deinked pulp. In all tests, residual peroxide content was slightly more than half of the added peroxide.

With alkaline deinked pulp, a NaOH dosage of 10 kg/t was used in the pulper, whereas no NaOH was used in reduced alkaline. Furthermore, in the case of reduced alkaline pulp 1 kg/t higher NaOH dosage than in alkaline pulp was used to assist post-bleaching. Therefore, the real NaOH dose was 9 kg/t smaller with reduced alkaline deinked pulp than with alkaline deinked pulp even if the initial pH of the peroxide stage was the same. Despite that, there were no big differences in the residual peroxide values. Thus, a higher alkalinity did not appear to notably increase the consumption of the peroxide for these pulps.

<table>
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<th>Table 4. Residual peroxide and pH for peroxide bleaching</th>
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<tr>
<td>Alkaline</td>
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<td>Reduced alkaline</td>
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The brightness development over the peroxide and dithionite bleaching sequence is shown in Figure 7.
In reduced alkaline deinking the brightness achieved after flotation is less than the brightness achieved in alkaline deinking. This gap in brightness after flotation obtained by reduced alkaline deinking compared to alkaline deinking can be essentially eliminated by post-bleaching with peroxide. The bleachability of the reduced alkaline deinked pulp was thus higher than alkaline deinked pulp in peroxide bleaching. In other words, the final brightness was at the same level even though the alkaline deinking pulp had an additional 6 kg/t of hydrogen peroxide to the pulper for a total of 26 kg/t for the alkaline chemistry while the reduced alkaline system only experienced a dosage of 20 kg/t in post-bleaching.

CONCLUSIONS

In the reduced alkaline deinking presented in this paper the use of sodium hydroxide and peroxide in pulping was eliminated from pulper without affecting the ink removal. The reduced alkaline deinked pulp was more responsive to the post bleaching chemicals than was the pulp processed using traditional alkaline deinked pulp. Post bleaching the pulps, obtained from both a traditional alkaline process and a reduced alkaline process resulted in the same residual ink and brightness values.

The TOC load in the process waters of the alkaline deinking gave almost two times higher TOC-load than reduced alkaline deinking.

References


