Effect of Ultrafiltration Permeate Recycling on Deinking Efficiency of Flexo-Printed Newspapers

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ABSTRACT

This study was carried out to determine the effect of ultrafiltration permeate recycling on deinking efficiency of flexo-printed newspapers. Wash filtrate effluents generated from various mixtures of old flexographic and offset newspapers and old magazines were clarified using ultrafiltration and sedimentation processes. Clarified waters were mixed with a deinked pulp sample to simulate a recirculation loop around the thickening stage. The effect of recycling water was assessed from brightness and effective residual ink concentration (ERIC) of washed pulp samples. Various deinking processes were also compared. Results show that ultrafiltration permeate did not decrease pulp quality while clarified water from sedimentation significantly affected both brightness and ERIC values especially for high flexo-printed levels in recovered paper furnish.

KEYWORDS


INTRODUCTION

Flexographic printing of newpaper has gained popularity in recent years due to printing advantages and for environmental reasons. However, old newspapers (ONP) printed with water-based flexographic inks are still difficult to recycle with existing deinking technology. Their presence even in small quantities in the raw material results in a loss of deinking efficiency and lower deinked pulp brightness (1-3) which limits the amounts of flexo-printed materials that can be processed by deinking mills.

Current deinking technology generally includes various combinations of flotation and washing stages to remove inks and contaminants from pulp suspensions. However, it is well established that the conventional flotation process is ineffective at removing flexographic inks (1-4). Under alkaline repulping conditions, flexographic inks are readily redispersed in the water phase to form stable dispersions of small hydrophilic particles typically less than one micron in diameter (3-7). Due to their small size and hydrophilic nature, these ink particles have little affinity for dispersed air bubbles. Therefore, they are poorly collected by air bubbles during flotation (3-5,7).

Conversely, the same properties that render flexographic ink dispersions difficult to remove by flotation deinking are suitable for removal by washing technology (3,8). However, the large volumes of filtrate produced by washing cannot be directly recycled to the process without detrimental effects on deinked pulp quality nor can it be discharged to the environment. Thus the overall economy of a wash deinking process is strongly dependent on removal of the ink from the washer effluent (9). Most deinking mills use dissolved air flotation (DAF) units to remove suspended solids such as inks, fillers and fibers from the process water because of its efficiency in solids removal (9). However, the presence of flexo-printed material in the furnish seriously impacts DAF clarification effectiveness and requires significantly higher levels of coagulant and/or flocculent to achieve a
proper clarified water quality (10,11). Less than satisfactory ink removal in DAF process increases the build-up of fine ink particles in the water loops and causes a drastic reduction of deinked pulp brightness.

Membrane separation technology has recently been investigated by Upton et al. (12-14) for clarification of flexo ink laden water. Experiments were carried out with aqueous dispersions of water-based flexographic ink at concentrations typical of those found in wash deinking of newsprint. Their results showed that ultrafiltration and microfiltration were both capable of completely removing flexographic pigments from aqueous dispersions (12-14). Though the use of flexo-printed newspapers is increasing, limited studies on the application of membrane technology for the removal of ink pigments for real deinking effluents have been reported in the literature (15). Recently, Chabot et al. (16) have investigated the potential of ultrafiltration for the clarification of process water from a flexo-printed newspaper deinking facility. Results indicated that ultrafiltration is capable of completely removing ink pigments from effluent streams, thereby producing clear permeate. However, no attempt has been made to reuse permeate water in the deinking system. Very limited studies have been conducted to evaluate the influence of deinking mill waters on the deinking process (17). Since recirculation of process water is required for pulper dilution, screen and cleaner dilution, and pulp washing, it is important to evaluate the effect of ultrafiltration permeate recirculation on deinking efficiency of recycled paper furnish containing flexo-printed newspapers.

The objective of this work is to determine the effect of permeate recycling on deinked pulp quality. Various furnish containing flexo and offset-printed old newspapers (ONP) and old magazines (OMG) were deinked with laboratory deinking equipments. A bench top ultrafiltration apparatus was used to simulate dissolved air flotation (DAF) clarification was also carried out for comparisons. Clarified water from ultrafiltration or sedimentation was mixed with a deinked pulp sample to simulate a recirculation loop around the washing/thickening stage and their effects were assessed by brightness and effective residual ink concentration (ERIC) measurements of resulting pulps. Various deinking alternatives were also simulated to evaluate the applicability of ultrafiltration for treatment of wash deinking effluent.

**EXPERIMENTAL**

**Furnishes**

Old flexographic and offset printed newspapers (ONP) were obtained from a newspaper printer and a deinking mill respectively. Newspapers were approximately nine months old. Old magazines (OMG) from a single source were also used as part of the furnish. Papers have been stored in a temperature and humidity controlled room prior to their use.

Furnishes containing 100% ONP and mixtures consisting of 70% ONP and 30% OMG were used. In both cases, the flexo-printed newspaper content was adjusted to between 10% and 100% of the recycled paper furnish.

**Deinking**

A schematic diagram of the basic steps involved for deinking wastepapers by a conventional deinking process is presented in Fig. 1. Repulping was carried out in a laboratory pulper (Adirondack Machine Corp., Glens Falls, NY) operated for 15 minutes at a pulp consistency of 3% and a temperature of 45° C. A standard deinking chemical recipe: 1% sodium hydroxide, 1% sodium silicate (42° Bé), and 0.1% nonionic surfactant was used for all deinking trials. All chemical dosages were based on oven-dry paper basis.
After repulping, pulp slurry was diluted with tap water to 0.8% consistency. Flotations were then carried out in a Denver D12 flotation cell (Svedala, Colorado Springs, CO) for 5 minutes at 1200 rpm and 45°C in a 10 L stainless steel container. Foam was manually scraped off from the surface of the cell. The accepted pulp from the flotation cell was kept for thickening. The pulp suspension (accepts) was diluted with tap water to 0.45% consistency prior to thickening. Thickening of the pulp was carried out on a 150-mesh screen in order to increase the pulp consistency from 0.45% to about 10%. The filtrate was collected for ultrafiltration and sedimentation treatments.

Ultrafiltration and Sedimentation

Wash filtrate effluent was prefiltered using a bag filter (Cole-Parmer, Vernon Hills, IL) with a nominal pore size of 100 µm to remove fibers and fines. Ultrafiltration experiments were performed with a polysulfone hollow fiber ultrafiltration membrane with a nominal molecular weight cut-off of 500,000 Daltons (13). The experiments were carried out with a bench-top membrane filtration apparatus following the experimental procedure described in detail in our previous study (16).

Sedimentation was performed on wash filtrate collected before bag filtration. A constant dosage of coagulant and flocculent was used throughout the clarification tests. The untreated wash effluent (8 L) was placed in a bucket and agitated with an electric stirrer at 100 rpm. The coagulant (20 ppm) was then added to the filtrate and mixed for 3 minutes. Mixing was then reduced to 40 rpm, the flocculent (10 ppm) was added, and the mixing continued for an additional 3 minutes. Mixing was then stopped to allow the flocs to settle for 10 minutes. Clarification efficiency was determined from turbidity of feed and permeate samples collected during ultrafiltration as well as untreated and clarified water from sedimentation. Turbidity was measured using a Hach 2100N turbidimeter (Hach, Loveland, CO).

Brightness Pad Preparation and Analysis

Pulp samples were collected after thickening and/or flotation for sheet-making. In each experiment, a pulp sample was diluted with tap water, ultrafiltration permeate or clarified water after sedimentation. For each mixture, two brightness pads (4.0 g) were prepared according to TAPPI Method T218 om-91. Pulp suspensions were previously acidified at pH 3 before pad making to retain all flexographic ink in the fiber mat during formation (18). Pulp samples were filtered on a Whatman 50 filter paper (Whatman Corp., Clifton, NJ).

Deinking efficiency was determined from brightness and effective residual ink concentration (ERIC) measurements on pulp samples collected after each deinking stage. Brightness was measured with a Photovolt 577 reflectance meter (Seradyn Photovolt Instruments, Indianapolis, IN) on the top side of brightness pads. Effective residual ink concentration (ERIC) was measured with a Technibrite Micro TB-1C (Technidyne Corp., New Albany, IN) using the method developed by Jordan and Popson (19).

RESULTS AND DISCUSSION

Effect of Recycling Clarified Water on Deinked Pulp Quality

Newspaper mixtures.

In this first series of experiments, furnishes containing only ONP printed by both offset and flexographic processes were deinked according to the conventional deinking process illustrated in Fig. 1. Figure 2 presents brightness and ERIC values after each deinking stage. This figure shows the well known detrimental effect of the presence of flexographic ink on deinked pulp quality. Brightness after pulping decreased significantly for flexo content higher than 20%. This decrease in brightness can be attributed to the presence of a higher quantity of small flexographic ink pigments released in the pulp slurry during pulping under alkaline conditions. This effect is also indicated by the higher effective residual ink concentration (ERIC) which gives information on the amount and dispersion of ink in a pulp sample (19).

The flotation stage carried out after pulping produced only limited brightness gains and ERIC reductions in furnish containing flexo-printed paper. Brightness after pulping decreased significantly for flexo content higher than 20%. This decrease in brightness can be attributed to the presence of a higher quantity of small flexographic ink pigments released in the pulp slurry during pulping under alkaline conditions. This effect is also indicated by the higher effective residual ink concentration (ERIC) which gives information on the amount and dispersion of ink in a pulp sample (19).

The flotation stage carried out after pulping produced only limited brightness gains and ERIC reductions in furnish containing flexo-printed paper, indicating that flotation was ineffective at removing flexographic ink particles. Those results are consistent with other studies (1-4,11) and are mainly attributed to the small size of flexographic ink particles and to their lack of hydrophobic character, both of which limit their effective removal by air bubbles in a flotation cell (3-7).

The thickening stage following flotation was more effective at removing flexographic ink as shown in Fig. 2. Results showed that higher brightness gains were achieved after thickening with higher proportion of flexo-printed materials in the furnish.
Figure 2: Brightness and ERIC values after each deinking stage for ONP furnish containing various proportions of flexo-printed ONP.

Surprisingly, the final brightness and ERIC values were approximately similar irrespective of the flexo ink content in the furnish indicating that the thickening stage was particularly efficient at removing flexographic inks. Although the thickening efficiency increased with the flexo content, it is clear that flexographic ink redeposition on fibers reduced final brightnesses compared to the final brightness of a deinked pulp obtained from a furnish containing 100% offset newspapers. Chabot et al. (20) and Ben et al. (21) have shown that significant redeposition of flexographic ink particles occurs during thickening, in agreement with pilot plant observations by Galland and Vernac (1).

Filtrate collected from the thickening stage was treated by ultrafiltration and sedimentation. Clarified water resulting from ultrafiltration (permeate) and sedimentation were then used to dilute thickened pulp samples and filtered to form pads. A control experiment was also carried out with tap water for comparison. Figure 3 shows that ultrafiltration permeate did not significantly affect brightness and ERIC values of deinked pulp. Similar results were obtained with tap water indicating that permeate can be recycled back to the deinking process without a detrimental effect on deinked pulp quality.

Reuse of sedimentation clarified water for flexo content of up to 20% did not significantly decrease the pulp quality. However, it is clear that at a higher flexo content (50%), the higher turbidity of the clarified water (42 NTU) affected both brightness and ERIC values of deinked pulp. As flexo content increased, turbidity of the clarified water from sedimentation increased from 20 NTU to 42 NTU due to the presence of remaining flexographic ink pigments. This indicates a decrease in the clarification efficiency of the sedimentation process. In contrast, turbidities of ultrafiltration permeates were lower than 1 NTU and no carbon black particles were detected.

Although permeates did not contain any carbon black pigments, they all showed a slight yellow to red tint possibly indicating the presence of yellow or red dye from printing inks or other unidentified dissolved compounds. It is likely that the molecular...
weight cut-off of the ultrafiltration membrane used (500,000 Daltons) was not small enough to retain those small components while all carbon black particles were removed from the feed stream.

Figure 4 compares the clarification efficiency of both ultrafiltration and sedimentation at various flexo levels. Results indicated that ultrafiltration was more efficient than the standard sedimentation process at all flexo-printed contents studied. The efficiency of ultrafiltration remained constant while sedimentation efficiency clearly decreased at higher flexo content. Although sedimentation experiments have been carried out at constant coagulant and flocculent dosages, results clearly indicated that sedimentation was more sensitive to the presence of flexographic ink, in agreement with previous studies from Schriver and Friel (10) and Tremont (11). On the other hand, ultrafiltration was not affected by the amount of flexographic ink in the wash filtrate and produced very high clarification efficiencies. Sedimentation efficiency could probably be improved with optimum coagulant and flocculent dosages especially at higher flexo ink content. However, this improvement in efficiency will be obtained at the expense of a higher treatment cost.

Newspapers and magazines mixtures.

Blending of old newspapers (ONP) and old magazines (OMG) is a common practice in modern deinking plants. Typical ratios of ONP/OMG range from 70/30 to 50/50, depending on furnish quality and deink pulp quality targets (22). In this second series of experiments, furnishes of 70% ONP and 30% OMG were examined. Flexographic ONP content was adjusted to produce 10%, 20%, 50% and 70% flexo substitution rates and were deinked using the same conventional deinking process illustrated in Fig. 1. Figure 5 presents brightness and ERIC values after each deinking stage.

The addition of flexo-printed ONP in the furnish significantly decreased brightness of the pulp after pulping. Concurrently, ERIC values after pulping nearly doubled. As in the previous series of experiments with furnish containing only ONP (Fig. 2), the addition of flexo-printed materials resulted in the release of a large quantity of very small hydrophilic flexographic ink pigments which drastically decreased brightness and increased ERIC values of the pulp after pulping.

The flotation stage following pulping showed a trend similar to what was observed previously for newspaper mixtures alone. Brightness gains after flotation were very low and decreased as flexo-printed...
content increased. Surprisingly, brightness gains observed were very similar to those found for ONP mixtures (Fig. 2) indicating that the flotation efficiency was similar for both furnishes. It is likely that the presence of fillers did not improve ink removal efficiency across the flotation cell as it is sometimes suggested in the literature (22–23). Therefore, the higher brightness values observed for ONP/OMG furnishes (Fig. 5) compared to those obtained for ONP furnish alone (Fig. 21, could be attributed to the retention of white fillers and brighter chemical fibers originating from OMG (24–25).

Although after pulping and flotation a significant decrease in the brightness was observed for increasing flexo-printed content in the recovered paper furnish, the thickening stage following flotation significantly improved both brightness and ERIC values (Fig. 5). Brightness and ERIC values were very similar at all flexo contents studied due to the high flexographic ink removal efficiency by the thickening stage.

Figure 6 presents brightness and ERIC values of deinked pulp samples mixed with ultrafiltration permeate or clarified water after sedimentation. Tap water was also used as a control experiment. Turbidity of both permeate and clarified water are also reported.

Dilution of deinked pulp after thickening with tap water or permeate resulted in very similar brightness and ERIC values (Fig. 6) at all flexo content studied. Therefore, permeate recycling did not affect pulp quality indicating that the ultrafiltration process was very effective at removing carbon black particles present in the wash deinking stream. Turbidities of permeates were very low ranging between 0.4 NTU to 0.5 NTU.

Clarification by sedimentation also showed good results for up to 20% flexo-printed ONP in the furnish. Although turbidities of corresponding clarified water (<0.5 NTU) were higher than permeate turbidities (0.4 NTU), they did not significantly affect deinked pulp quality. Brightness and ERIC values were in the same range as trials with tap water or permeate. However, at higher flexo inclusion rates (50%-70%), sedimentation effectiveness decreased significantly, indicated by the higher turbidities (130-150 NTU), resulting in lower brightness and higher ERIC values. Results showed that the reuse of ultrafiltration permeate did not affect pulp quality while the reuse of sedimentation clarified water from furnishes containing a high flexo-printed ONP content had a detrimental effect on both brightness and ERIC values of deinked pulp.

Figure 7 presents clarification efficiency of both ultrafiltration and sedimentation of wash deinking filtrates. Results showed that ultrafiltration efficiency was not affected by the wash filtrate composition while sedimentation efficiency was clearly reduced as the flexo-printed content in the recovered paper furnish increased. Ultrafiltration efficiency remained close to 100% resulting in clear permeate for all flexo inclusion rates studied. In contrast, sedimentation efficiency dropped significantly for furnishes containing 50% or more flexo-printed ONP, producing more turbid clarified water.

Results also showed differences between ultrafiltration and sedimentation clarification efficiency increased with flexo-printed content clearly indicating that the presence of water-based inks in washer filtrates significantly affected the performance of the sedimentation process which is in agreement with previous studies on dissolved air
Figure 7: Clarification efficiency for ultrafiltration and sedimentation of wash filtrates from ONP/OMG furnishes containing various proportions of flexographic ink.

Comparison of clarification efficiency for ONP/OMG furnishes (Fig. 7) and ONP furnishes (Fig. 4) revealed that efficiencies of both ultrafiltration and sedimentation were approximately in the same range suggesting that the presence of fillers did not have a detrimental effect on clarification performance. A recent study on the clarification of deinking process water has shown that different types of fillers and their concentrations could have various positive and negative effects on the clarification process (26).

Ultrafiltration Stage in Deinking Processes

In general, multi-stage processes including combination of flotation and washing stages are required to deink furnishes containing flexo-printed newspapers. Since 1991, various processes have been proposed for deinking such furnishes (1, 8, 27-30). To study the possibility of improving deinking processes by incorporating an ultrafiltration stage to clarify wash deinking filtrate containing flexographic inks, two deinking processes have been simulated in laboratory. A conventional flotation deinking process followed by three stage thickening (Float/Thick) (a was compared to a washing/thickening deinking process followed by flotation (Thick/Float) (28). Trials were carried out under alkaline conditions with a furnish blend of 70% ONP and 30% OMG. The flexo-printed ONP content was adjusted at 20% and 50%. To simulate clarified water recycling, tap water, ultrafiltration permeate, or clarified water after sedimentation was used to dilute incoming pulp before the last deinking stage. For example, dilution with clarified water was carried out before the second and the third thickening stage for the Float/Thick process and before the flotation stage for the Thick/Float
process. Figures 6 and 9 present brightness and ERIC values for deinked pulp after each deinking stage for both processes. The effect of clarified water recycling on final deinked pulp brightness and ERIC values for both processes is also summarized in Table I.

Flotation followed by three stage thickening.

At low flexo-printed ONP content (20%), interstage dilution before thickening stages with tap water or ultrafiltration permeate (UF) increased brightness significantly while dilution with clarified water after sedimentation (Sed) produced only a limited brightness gain (Fig. 8). Brightness gains observed were thus associated with ERIC value reductions (Fig. 9).

At high flexo-printed content (50%), a similar brightness gain and ERIC reduction was observed when using tap water or ultrafiltration permeate as interstage dilution water. However, no brightness gain and no significant ERIC reduction were found with clarified water after sedimentation. The lower brightness gain or ERIC reduction observed with clarified water after sedimentation were caused mainly by the decrease in the clarification efficiency of the sedimentation process as shown previously with the same ONP/OMG furnishes (Fig. 7). Therefore, it is clear that recycling of ultrafiltration permeate around thickening stages did not impair pulp quality as was the case for clarified water.

Thickening followed by a flotation stage.

In this series of experiments, two conditions were studied for the flotation stage. In the first part, no collector was added prior to flotation, while in the second part, 0.2% nonionic surfactant was added. Results indicated that at low flexo-printed content (20%), when no collector was added a brightness gain of 5 to 6 units (Fig. 8) and a reduction of ERIC (Fig. 9) was achieved across the flotation stage. However, the final brightness obtained was similar (50%) in all cases.

Addition of a collector prior to flotation improved significantly the final brightness (2-4 units) with a substantial reduction of the ERIC values. Surprisingly, recycling of permeate or clarified water from sedimentation resulted in lower pulp brightnesses and higher ERIC values compared to tap water (Table I). Two possible reasons related to an overdosage of the nonionic surfactant in both permeate and clarified water could explain this unexpected result. According to the data (Table I), the brightness decrease is related to the presence of more ink particles remaining in the pulp suspension as indicated by higher ERIC. On the other hand, this brightness loss could also be partly attributed to fiber and filler loss in the reject during the flotation stage. Larsson et al. (31) have shown

![Diagram showing the process flow for flotation followed by three stage thickening and thickening followed by flotation.](http://example.com/diagram.png)
Table 1. Effect of Clarified Water Recycling on Final Bright less and ERIC Values for Float/Thick and Thick/Float Sequences.

<table>
<thead>
<tr>
<th>Flexo Content Dilution (%)</th>
<th>Float/Thick</th>
<th>Thick/Float No collector</th>
<th>Thick/Float 0.2% collector</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Brightness (%)</td>
<td>ERIC (ppm)</td>
<td>Brightness (%)</td>
</tr>
<tr>
<td>20 Water</td>
<td>52.9</td>
<td>427</td>
<td>50.8</td>
</tr>
<tr>
<td>UF</td>
<td>53.7</td>
<td>398</td>
<td>48.8</td>
</tr>
<tr>
<td>Sed</td>
<td>50.0</td>
<td>592</td>
<td>49.6</td>
</tr>
<tr>
<td>50 Water</td>
<td>53.5</td>
<td>303</td>
<td>46.7</td>
</tr>
<tr>
<td>UF</td>
<td>53.8</td>
<td>285</td>
<td>45.7</td>
</tr>
<tr>
<td>Sed</td>
<td>47.5</td>
<td>617</td>
<td>42.8</td>
</tr>
</tbody>
</table>

that addition of an excessive nonionic surfactant dosage decreased ink particle floatability. Furthermore, Dorris and Page (32) have shown that during flotation, an excessive frother concentration increased froth stability which reduced ink particle hydrophobicity and increased water loss in the flotation rejects. As water loss increased, more hydrophilic particles such as fibers and fillers, were entrained in the rejects. Therefore, lower ink particle removal by flotation and entrainment of fibers and fillers in the reject could be partly responsible for the lower final brightness observed with permeate and clarified water after sedimentation. At high flexo-printed content (50%), brightness gains of 3 to 4 units (Fig. 8) and corresponding ERIC reductions (Fig. 9) were observed when no collector was added before flotation for pulps diluted with tap water or ultrafiltration permeate. On the other hand, no significant brightness gain or ERIC reduction was observed for pulps diluted with clarified water after sedimentation, in agreement with previous results. Addition of a collector chemical prior to flotation improved both brightness and ERIC values for all cases.

Comparison of the two deinking sequences indicated that in general, flotation followed by three stages of thickening (Float/Thick) resulted in slightly higher final pulp brightness and lower ERIC than thickening followed by the flotation process (Thick/Float) (Table I). This behavior was observed for each type of clarified water used for dilution and at the two flexo-printed ONP inclusion rates (20% and 50%) studied. Galland et al. (30) have recently compared various deinking sequences at the pilot scale level. Contrary to our results, they reported better final pulp brightness for washing followed by a flotation as compared to results obtained with flotation followed by three washing stages. Obviously, those discrepancies could be attributed to various factors such as heterogeneity of the raw materials, different types and compositions of ink, aging effects, and chemistry used for deinking. We have also carried out our experiments at the laboratory scale. Borchardt (33) has shown that process performance properties such as brightness, ink speck count, and yield loss can be affected by scale-up. Although laboratory flotation deinking brightness values scaled-up well in the pilot-scale tests, yield loss values showed significant differences (33). On the other hand, laboratory thickening stages were carried out by pouring the pulp slurry on a screen without mat pressing. It is likely that contaminant removal efficiency is affected by the washing/thickening equipment design. At the pilot or industrial scale level, equipment operating conditions such as wire mesh or screen size, production rate, feed and discharge consistencies as well as pulp characteristics such as freeness and fines content, mechanical and chemical fibre contents, filler and/or clay contents will affect washing efficiency and thus equipment performance (8, 34). Since ink removal efficiency depends on such various parameters, it is clear that some or all of those parameters could affect ink removal and explain variations in the brightness and/or ERIC values of the deinked pulp.

CONCLUSIONS

This study examined the effect of ultrafiltration permeate recycling on deinking efficiency of flexo-printed newspapers. Experiments have been carried out with furnish blends of ONP with and
without OMG, both containing various proportions of flexo-printed ONP. The study focused on the determination of potential detrimental effects of permeate recycling on deinked pulp quality, mainly brightness and ERIC. The results can be summarized as follows:

In all cases, treatment of wash filtrates by ultrafiltration produced clean permeates, free of detectable carbon black pigments, while standard sedimentation treatment efficiency decreased significantly when the flexo-printed ONP content increased to levels higher than 20%. Therefore, ultrafiltration was less sensitive to flexographic ink concentration than sedimentation process.

Reuse of ultrafiltration permeate to deink furnishes of ONP blends with or without OMG did not significantly affect brightness and ERIC values of deinked pulp at all flexo-printed ONP content studied. Comparison with tap water showed similar results. However, for the same furnishes, the reuse of clarified water from standard sedimentation significantly reduced both brightness and ERIC values when flexo-printed ONP content was higher than 20%.

Comparison of two laboratory multi-stage sequences to simulate existing industrial deinking processes has shown that ultrafiltration permeate can be used as dilution water before thickening or flotation stages without detrimental effect on final deinked pulp quality at all flexo-printed ONP inclusion rates studied. Although clarified water after standard sedimentation for both sequences did not affect pulp quality at low flexo content (20%), our results showed a significant decrease in pulp quality at higher flexo content (50%). Addition of a collector prior to the flotation stage in the Thick/Float sequence was found to significantly improve pulp brightness and ERIC. However, it seems that the remaining surfactant in both permeate and clarified water after sedimentation had a slight detrimental effect on flotation efficiency as compared to tap water.

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