The Influence of Different Digital Printing Techniques on the Print Recycling Efficiency

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ABSTRACT

The principle of the digital printing process and toner types effect on deinkability of prints. The influence of the deinking conditions (chemical, enzymatic) on the mechanism of the process and the characteristics of the recycled fibre is discussed in this paper. The application of enzymes in deinking flotation of digital prints, increases brightness and decreases less the mechanical properties of the recycled fibres. For evaluation of the recycled efficiency the optical and microscopic method as well as image analysis were used.

INTRODUCTION

The recycled fibres are more and more important source for the production of printing papers. The recycling process includes detachment of ink from fibres, removal of detached ink from pulp and water clarification for reuse and disposal of removed ink and stickies. Mechanical, chemical and thermal forces are utilized to detach ink from the fibres. The efficiency of the deinking flotation in removing the ink from the prints in the recycling process is determined among other things by ink types and printing process (2). Each printing technique, starting from the conventional ones (offset, gravure, relief, flexo printing and screen printing) to the digital ones (on the principle of electrophotography, ion deposition, electostatic, magnetography and electrography) set different tasks on inks, toner respectively, in order to satisfy the given principles of the process. Unlike conventional printing inks, toners in digital printing based on electrophotography contain synthetic binders based on polyester or copolymers of styrene with acrylates, methacrylates and butadiene, charge control agents (quaternary ammonium salts, sulphonates, zinc complexes), colorant (pigment or dye) and other technical additives. Mentioned thermoplastic resins exhibit a glass transition temperature of around 65-70 °C, at which point they soften and flow. In the printing process the toner is electrostatically transferred to the paper and heat fused into the substrate. By Indigo print press are used polymeric liquid toner or electrolink. The electronk is sprayed onto the photosensing drum and heat softened of around 28-30 °C. It hardens on contact with the paper through a polymer cross inking process. These characteristics significantly effect to deinking efficiency (3). The influence of the digital prints in deinking process (chemical, enzymatic) on the mechanism of the process and optical and mechanical characteristic of the recycled fibre are discussed in this paper.

EXPERIMENTAL

The samples of multicolour prints obtained by the direct digital printing Xerox with powder toner and digital offset printing Indigo with liquid toner were used. All the prints were made on the same printing substrate. For chemical deinking process in the phase of prints soaking 1% sodium hydroxide, 1% hydrogen peroxide, 2% sodium silicate and 0,1% synthetic colector, nonionic surfactant based on alcoxylated fatty acids were used. The suspension concentration 12% in regard to the dry substance is used. Suspension was diluted and defibred after soaking. The sample was disintergrated with 120000 resolutions. Suspension was diluted to concentration of 0,6 % and it was put into flotation cell. Handsheets were made after disintegration and flotation according to TAPPI standard methods T 201. Enzyme preparations is diluted 1:100 before application to fibres and the appropriate amount of dilute enzyme to the remaining required dilution water to give 0,1 ml/kg based on o. d. weight of pulp. Standard methods for measurement mechanical and optical properties of the fibres are used.

RESULTS AND DISCUSSION

For the success of the chosen deinking process the chemistry of the system in the disintegrator is important in fibre swelling, wetting of the ink particle, ink removed, agglomeration, flocculation and oxidation-reduction of chromophores. By using sodium hydroxide, pH value of the suspension is set to 10. The cellulose fibres in this process accept water, swell and become more flexible. This and the movements in disintegrator contribute to the toner removal. Figure 1. presents the handshees after disintegration of Xerox and Indigo prints.

Figure 1. Toner and electronk particles after disintegration

From this presentation it is visible that the toner particles are flat, some smaller ones are completely separated and they have no cellulose fibre traces on them. However, the
particles, which are completely toner – fibre aggregates can be noticed. The results of the image analysis show more particles on handsheets after disintegration of Indigo prints versus Xerox, as it can be seen in figure 2.

![Image of particle size range mm²](image)

**Figure 2.** Results of the image analysis of handsheets after disintegration (chemical deinking)

The polymerisation of toners during printing process results with the formation of larger particles. It makes cellulose fibres chemically bonded to toner particles and physically captured in particles, what makes toner particle more hydrophilic. The oxidation contributed greater polarity at toner surface. All that is also the cause of poor floatability. The particle size in disintegration is not influence much by the enzyme application in the described experimental conditions adjusted to their activity, primarily by the defined pH and temperature. It is interesting to see the results of the image analysis and compare the residual ink on handsheets prepared from each flotation process (figure 3).

![Image of residual ink mm²](image)

**Figure 3.** Effect of deinking flotation on residual toner

The influence of the enzymes is recognizable in processing both kinds of prints (Indigo, Xerox). Because the results of the image analysis do not show essential differences among the toner particles by using the chemicals or enzymes in deinking, it is probable that the enzymes act on surface properties of the particle, which contributes to their better removal in the flotation process.

![Image of loss of substances %](image)

**Figure 4.** Loss of substances in deinking process

The following characteristic of the enzymatic process is greater removal of filler and greater fibre disintegration in enzymatic process in regard to the chemical deinking in the given experimental conditions.

The results of the measured brightness of the handsheets after disintegration and flotation of sample speak about the efficiency of the process itself, as shown in the table 1.

<table>
<thead>
<tr>
<th>Process</th>
<th>Xerox after disintegration</th>
<th>Xerox after flotation</th>
<th>Indigo after disintegration</th>
<th>Ind. after flotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chem. deink</td>
<td>73.5</td>
<td>80.8</td>
<td>71.0</td>
<td>78.3</td>
</tr>
<tr>
<td>Enz. deink</td>
<td>74.7</td>
<td>84.8</td>
<td>72.2</td>
<td>81.9</td>
</tr>
</tbody>
</table>

Greater growth of brightness is obtained for the handsheet prepared after flotation enzymatic treated prints. In general, the measurement of brightness is not only affected by the quantity of residual ink, but also by the size of the ink particles. Smaller ink particles had greater detrimental impact on brightness by the same quantity of residual ink.

By using the enzymes, the decrease of some mechanical properties of the recycled fibres was noticed. The example of values for the burst index, which was decreased for 1.48 N/m² and 1.65 N/m² Indigo in enzymatic process in regard to the chemical deinking, will be shown. However, sodium hydroxide was used in chemical process. Sodium hydroxide, which is present in the deinking chemicals strength enhancement, and on this way possible contributed to the higher burst index.

**CONCLUSIONS**

It is visible in the scope of these experimental conditions that the applied enzyme can facilitate deinking of prints of the tested digital printing techniques and give contribution to flotation efficiency. The quantity of residual toner on handsheets prepared after flotation process and handsheets brightness lead to such conclusion. However, the decrease of some mechanical properties of fibers was noticed, such as values for the burst index. This data is especially interesting so that such recycled fibers could be used for newsprint paper production for printing on offset rotary machines. Except that, greater loss of filler removal and the loss of fibers in regard to the chemical deinking process are noticed during flotation.

Because the usage of the digital printing techniques grows, the further investigation was justified.

**REFERENCES**