MODIFICATION OF RECYCLING PROCESS FOR INKJET PRINTED PAPER

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ABSTRACT

The use of secondary fibers is quite common during the manufacturing process of recycled papers. Paper quality and the use of energy is so important for the paper recycling process. It is also important to reduce the amount of energy used during this process. For this reason, in this study; during the recycling of the inkjet printed papers, both the standard INGEDE method 11p deinking process and the process without deinking were applied. All handmade sheets and filter pads’ optical values were measured according to T 452 Brightness values (directional reflectance at 457 nm), T 524 L, a*, b* values (45/0 colorimetry of white and near-white paper) and Luminosity Y values (557 nm, C/2° and D65/2° light sources). Obtained results were compared with each other and shown in graphics.

Keywords; Paper recycling, deinking, flotation, inkjet ink

INTRODUCTION

Recycled fibres play a very important role today in the global paper industry as a substitute for virgin pulps. Paper recovery rates continue to increase each year in most parts of the world. The recycling rate in Europe reached 70.4% in 2011. [1] The European Paper Recycling Council (EPRC), formerly known as European Recovered Paper Council, has announced a new recycling target. After a recycling rate of 71.5% in the European Union in 2015, the organization now envisages a rate of 74% to be achieved by 2020. [2] This shows that paper recycling rate will geting increase.

Figure 1. European paper recycling rates between 1991-2012 [3]

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Paper recycling is a large scale, multi-step process with the objective to recover the paper fibers, and often other paper components such as mineral fillers, and use them as a raw material to produce new paper. [4]

Recycling of waste paper requires the removal of printing ink from the paper by a process called deinking. Deinking which involves the removal of printing ink, mainly consists of two steps i.e. the detachment of ink particles from the fiber surface followed by the removal of detached ink from the pulp slurry by washing or floatation [5]

In flotation, the ink is separated from the fibers by the injection of air in the presence of a foaming agent. Rising bubbles (foam) carry away the ink particles which are separated from the top of the flotation vat (Figure 2). Some fibers are lost in the reject stream or froth (foam and ink) and therefore the fiber yield is less than 100%. Likewise, some ink particles remain in the fiber accepts and therefore the final paper quality depends on the selectivity of the separation process. [6]

![De-Inking Schematic](image)

**Fig 2.** Deinking process [7]

Especially water-based inks like flexography, gravure and inkjet prints are three typical inks that are hard to remove via flotation deinking. [8] For effective deinking, it is very important to prevent the re-deposition of ink particles onto the fibers prior to removal. [9] The reason why the flotation method does not work in these three printing systems is the particle size of the colorants. The pigment size of the offset printing inks between 10 and 250μm, but inkjet ink particle size is just 0.1-2μm, because of this reason removal of inkjet ink pigments from fibre is harder than offset printing inks. [10] This makes it difficult to separate the inks from the paper fibers.

**Experimental part**

In the study; the Epson Stylus Pro 9800 inkjet printer was used for printing. Only black ink was printed on the Epson Enhanced matte paper. Because, the black ink is difficult to remove from the fibers. For accelerated aging, printed samples were torn into 2x2 cm$^2$ pieces and oven dried (OD) for 72 hours at 60°C. After aging, first, INGEDE method 11p process was used with standard chemicals (Table 1) for recycling papers. Second, the commercial bleaching...
CLOROX (include 8.25% sodium hypochlorite solution) was used for bleaching. This solution was named bleaching agent A in the study. The process of using bleaching agent A; firstly, 40g OD pieces papers were weighted, then pulped. Micro-Maelstrom pulper was used for 10 min to create the pulp slurry at temperature 45°C, (40g OD, and 300 ml H\(_2\)O (with CaCl\(_2\))). Then, 1 min. mixed with adding 100g bleaching agent A, and pulper speed was 500 RPM. (pH: 8.53) then added 1000ml H\(_2\)O (with CaCl\(_2\)) and waited 1 hour. During this waiting time, flotation method was not used. After 1 hour 4000 ml H\(_2\)O (with CaCl\(_2\)) added (pH: 7.22) and then hand sheets were made.

### Table 1: Standard solution formula for preparing pulp [8]

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Rate (Dry Fiber Base)</th>
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<tbody>
<tr>
<td>NaOH</td>
<td>0.6% (100%)</td>
</tr>
<tr>
<td>Sodium Silicate</td>
<td>1.8% (1.3-1.4 g/cm(^3))</td>
</tr>
<tr>
<td>H(_2)O(_2)</td>
<td>0.7% (100%)</td>
</tr>
<tr>
<td>Oleic acid</td>
<td>0.8% (extra Pure)</td>
</tr>
</tbody>
</table>

Water hardness and water temperature was kept under control during all recycling processes. During laboratory experiments, only deionized water was used. Each step of the experiment was heated up to a considerably high temperature by means of the hot-water heater, and successively cold dilution water was added until the desired temperature was reached, 45°C.

### Results

**Brightness:** Comparisons of brightness values according to TAPPI test method T 452 om, (directional reflectance at 457 nm) are shown in Figure 3.

![Brightness values](image)

When compare the brightness values, bleaching agent A values are higher than the INGEDE method results and they are closer to unprinted recycled paper values.
Luminosity: Comparisons of luminosity (Y) by C/2° and D65/2° light sources are shown in Figure 4.

![Figure 4. Luminosity (Y) values](image)

When compare the Luminosity Y values measured via C/2° and D65/2° conditions, the Luminosity Y values of bleaching agent A are higher than the INGEDE method results.

CIE a*: Comparisons of CIE a* values are shown in Figure 5.

![Figure 5. CIE a* values](image)

When compare the CIE a* values, the CIE a* values of bleaching agent A are worse than the INGEDE method results.

CIE b*: Comparisons of CIE b* values are shown in Figures 6.
When compare the CIE b* values, the CIE b* values of bleaching agent A much closer to unprinted recycled paper.

**Conclusion and Comments**

This work was focused on recycling digital printed papers via INGEDE Method 11p and its modification. In the use of bleaching agent A, unlike the INGEDE method 11p, the flotation method hasn’t been used, because of this reason recycling time took shorter than INGEDE method 11p.

When we compare the results of the bleaching agent A and Standard INGEDE method 11p, Brightness, Luminosity, and CIE b* values of bleaching agent A results are better than INGEDE methods 11p, however CIE a* value a little lower than the INGEDE method 11p. The values have been found closer when compared with unprinted recycling paper.

Pigments’ particle size in inkjet inks are very small, so it is very difficult to remove these particles from the fibers. Instead of removing the pigment particles, they may be decolorized or left in the paper as a filler.

**References**


https://projects.ncsu.edu/project/hubbepaperchem/DEIN.htm 15.09.2018

