What Makes a Digital Print Recyclable?

Results of a European Survey

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Abstract

Digital printing is being used more and more. Most technologies are well accepted but pose some difficulties with respect to deinkability and paper recycling. Worldwide, approximately 50 % of the paper is recycled. Digital printing should not be a determinating factor in reducing or stabilizing this number. Most developers as well as printers are not aware of these difficulties neither of the existing differences in the printing processes in terms of the recyclability of the printed product.

The paper gives an outline on paper recycling to explain how problems can arise with some digital prints. It will deal with high speed printing processes, dye and pigment based inkjet, liquid and dry toners and UV curable technologies. Results obtained e. g. within a research project sponsored by INGEDE during the last three years at the CTP (Grenoble, France) suggest that oil based inks on coated paper and dry toner are the preferred technologies with respect to this matter [1]. First results of a European Survey on the deinkability of digitally printed papers will be presented.

Introduction: Paper recycling

Paper recycling is a cost effective and sustainable source of fibers for graphic papers (and hygiene papers). More and more paper is recovered all over the world. In Europe, newsprint is made of 100 per cent recovered fibers already. Even more paper has to be recovered, as the demand is still high. This leads to more impurities in the recovered paper. On the other hand, the resource "urban forest" is also used for higher qualities more and more often – these are the only potential to increase recycling rates in Europe. But this requires also a better quality of the raw material. Nevertheless, some paper mills are capable to produce copy paper, fine paper and coated offset paper from 100 per cent deinked pulp.

Deinking: How does it work?

The recovered paper contains a variety of contaminants. These can be removed by size differences (screens), density differences (cyclones) or their surface properties (flotation).

Deinking is the removal of the printing ink from the recovered paper. Flotation is the key process for the removal of printing ink in Europe, washing is more prevalent in the U.S., but even here more and more replaced by flotation (due to the disadvantage of washing: low yield).

Flotation

A suspension of re-pulped paper fibers with water, caustic soda, peroxide, silicate and soap is thoroughly mixed to support the ink detachment. Air bubbles are blown through the mixture. The bubbles carry ink particles away from the fiber to the surface where the resulting foam is skimmed off. The flotation can also remove some varnishes and adhesives.

To be removable by this process, the ink has to be hydrophobic. How the particles are removed depends also on their size:

- particles > 150 µm = screenable (as long as they are stiff!)
- 30 µm < particles < 300 µm = cleanable
- 10 µm < particles < 100 µm = flotable

If particles are smaller than 10 µm, they are hardly removable by these processes. Problems occur with water based inks, especially with almost all of the currently available flexo inks.

Dispersing and bleaching

In many deinking plants, the flotation is followed by a disperger which reduces the size of residual contaminants like hot melt adhesives, varnishes or toners to become less visible or to become removable by a secondary flotation. A bleaching step uses peroxide or FAS.

Deinking of digital prints

Digital printing technologies are gaining a growing share of the market. In the near future, many of these printed products will end up in the recovered paper collection from households and offices, becoming part of the raw material to be recycled by papermakers.

But the deinkability of some digital prints could turn out to be a threat to today's paper recycling systems: although some of these prints deink quite easily, others lead to severe problems, which may endanger the entire deinking process. A series of tests performed by scientists of the French Centre Technique du Papier (CTP) in Grenoble has also shown that all water based inks lead to severe deinking difficulties.

Differences between processes currently on the market turned out to be surprisingly high.

Liquid toner can create problems for paper recycling

Particularly poor results were observed with the first generations of liquid toner processes such as the one used by Indigo, which claims market leadership in digital color printing systems. These printers use a fast drying, so-called electro-ink. The toner is transferred from a drum to the electrostatically charged paper, where it is fused to form a polymer film. When the printed paper is dissolved at the beginning of the recycling process, these films result in large but very soft and flexible particles. These particles can neither be removed by the usual screens nor through flotation. The result is a high number of clearly visible dirt specks in the recycled paper.

Not only that early Indigo prints themselves are not suitable for paper recycling, even small amounts of them can create problems if they enter the process mixed with other recovered paper.

After these results had been obtained, HP Indigo started developing a next generation of liquid toner. This new ElectroInk 4 is said to be better much deinkable. Independent investigations were not available before the deadline of this manuscript. Test results of this ink will be presented.

Washing is no solution

The conclusions of a recently published study [2] look promising at the first glance but ignore the conditions actually present in a paper mill. The authors find good removal for experiments "simply with disintegration and washing". Except at some older mills in the U. S., world wide the washing process is not used in industrial scale for the production of graphic paper due to high losses of fibers and water (*see introduction*).

Also the suggested ultrasound treatment looks impractical and too expensive for industrial application to a varying mixture of paper. Only if Indigo prints are collected separately from other paper and treated separately in a recycling plant especially designed for this purpose, this process will work, though the costs will far from an economical solution.

Dry toners do it better

Dry polyester toners, as they are applied for digital four color printing processes from Xeikon, Xerox, NexPress and others, create fewer problems. The resulting brightness and residual ink are sufficient to lead to good deinkability. A lot has been learnt about fusing conditions and how they affect the adhesion to the paper as well as the deinkability. Newspapers printed on Océ high speed printers can even result in higher brightness than conventional newspapers, mainly due to their lack in color (which is more difficult to remove than black ink even in conventional newspapers).

A future trend in dry toners is to lower the melting temperature. This could lead to problems in paper recycling as the particles might form elastic aggregates under the conditions of the deinking process. These aggregates are very difficult to remove.

Inkjet inks are hard to remove

The deinkability of inkjet prints varies. Most black inks today contain finely distributed pigments that can neither be deinked (the are too small to be removed by flotation) nor discolored (as intended to increase light fastness, they are not susceptible to bleach). As little as 10 per cent of print products with these inks mixed with other recovered paper is enough to spoil the deinkability of the whole mixture. Among the dye-based black inks only a few can be discolored efficiently. Yellow and blue inks cannot be bleached at all – they leave an even shade in the deinked pulp. Attempts to agglomerate hydrophilic pigment particles with chemicals have failed so far.

Inkjet printers are not only used in the office. To make mass mailings more attractive by personalization, increasing volumes of direct mail, bills, statements and manuals are printed at a speed of more than 2,000 pages/minute with inkjet printers. Even newspapers can be printed with inkjet printers today. Their deinkability has to be examined.

UV inks: Most of them leave too many specks

UV inks are developing quickly into different applications, leaving the packaging sector and offering ways to glossy finishing as well as to water based, fast drying inkjet inks. But UV ink particles can pass the flotation process as well as screens to end up as visible specks in the paper.

Regulatory consequences

As many digitally printed products can cause problems in the recycling process, the paper industry tries to communicate these problems to device and ink manufacturers. The question also arises how to keep non-recyclable products away from the recycling system that has been set up and designed basically for offset and gravure printed papers and magazines. Adapting the flotation process to the variety of new challenges is virtually impossible as the amounts vary and chemical as well as energy costs cannot be increased to keep recycled paper competitive.

In Europe, an Eco-label for printed products is under discussion. One of the criteria for this label will be recyclability. Many digital printing processes deliver products that will fail to fulfill the recyclability requirement. Further, if significant problems are observed, in some countries a label "non-recyclable" to be applied by the printer might become mandatory in order to inform the consumer who cannot tell one print process from another.

European Round Table – Test Form

In January 2006, on invitation of INGEDE a European Round Table on the Deinkability of Digital Prints met for the first time. Representatives of paper mills and printer manufacturers as well as research institutes and authorities discussed issues of recyclability.

In order to make deinkability testing better comparable, a test form was developed. This standard test form is available on INGEDE's website www.ingede.com. With this test form, prints have been made by several printer manufacturers and sent in to INGEDE. From there, they were given as unnamed samples to different research institutes to test the deinkability and also to be able to monitor the reproducibility of deinkability testing. At the same time, a set of data is collected to allow comparing printing parameters once the deinkability data have been collected.

Many printer manufacturers beyond the participants of the first round table have agreed to provide samples for the deinkability survey.

Who is INGEDE?

INGEDE is an international research organization of paper mills that recycle paper to produce graphic and hygiene paper. INGEDE already spent more than 5 mio € for research in deinking technology, deinkability of printed products, standardizing test methods and related research topics.

References

1. Bruno Carré and Laurence Magnin, Digital prints: A survey of the various deinking behaviours. Paper presented at the 7th Research Forum on Recycling, PAPTAC – TAPPI, Quebec, Canada, September 27-29, 2004
2. A. Fricker, A. Manning and Robert Thompson, Deinking of Indigo prints using high-intensity ultrasound, Surface Coatings International Part B: Coatings Transactions, Volume 89, Number 2, June 2006, pp. 145-155(11)

Author Biography

Axel Fischer studied chemistry at Munich Technical University. He worked as a Science Writer for TV, print media and Germany's major news agency. Since 1994, he is responsible for the public relations of INGEDE, the International Association of the Deinking Industry. Besides dealing with international media, he also represents the association at international events and working groups dealing with recyclability, with flexo inks and digital printing technologies and the consequences of recycling printed materials. He chairs the European Round Table on the Deinkability of Digital Prints.