Advances in Deinking and Deinkability of Inkjet Inks

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Abstract

With rising environmental awareness, paper recycling becomes a more and more important issue also in marketing of printers and – accordingly – in the development of a printer. Still little is known about coherences. During the recycling process, the ink is separated from the paper fibers dissolved in water, and then it has to be removed from the aqueous suspension. For this separation, soap and air create bubbles that transport the ink to the surface of a flotation cell. This works easily with hydrophobic particles such as most offset and gravure inks. But this basic principle is also why most current aqueous inkjet inks are difficult to deink.

INGEDE started communicating deinkability of digital prints in 2001 already to have this feature included as a development target. But it took until drupa 2008 until the major inkjet printer manufacturers realized that there is an issue. Still it is difficult to understand that the process to deink the mixture coming from household paper collection requires the process to work economically with the mixture rather than with single components.

The underlying procedure for deinkability testing is INGEDE Method 11. Occasionally is being discussed whether it is relevant for all deinking processes, not only in Europe, also in the US. The procedure allows a solid assessment under standard conditions but is not meant to simulate every detail of a specific deinking plant. The method is a long time consensus within the paper industry designed to detect the challenges that a print product means for the basic deinking steps.

Deinkability testing and INGEDE Method 11

A proper assessment of the deinkability of printed products was on the agenda of INGEDE's research activities for many years. For this assessment, deinkability tests carried out according to INGEDE Method 11 [1] serve as the basis for comparing deinkability of prints. This method had been published as draft for the first time in August 1999 in German language. In March 2009 the European Recovered Paper Council (ERPC) adopted the latest version of "Deinkability Scores" as assessment scheme. The ERPC is the committee of the signatories and supporters of the European Declaration on Paper Recycling.

Deinkability testing according to INGEDE Method 11 at laboratory scale simulates pulping and flotation, the two key process steps for ink removal. Before pulping the samples are aged artificially for three days which is equivalent to about a three month natural ageing. Pulping, storage and flotation are exactly defined in equipment and operating parameters [2, 3]. The original concept of INGEDE Method 11 is to work with a fixed dosage rate of deinking chemicals. The reasons are better comparability of the results and easier, less time consuming execution in the laboratories compared to the definition of a fixed pH. Recent research and testing work, however, showed that certain printed products (in this case acidic newsprint from Scandinavian countries) result in a pH shift which goes beyond the normal operating range in industrial deinking plants. In the revised version of INGEDE Method 11 therefore the pH acts as a "sentinel" for an adaptation of the chemical dosage, if necessary. This made INGEDE Method 11 suitable for a wider range of printed products and better reflects the paper influence also in digital prints on wood free paper.

INGEDE Method 11 looks at five parameters. The first three are quality parameters characterizing the deinked pulp in brightness and cleanliness (luminosity Y, dirt particle area A). The dirt particle area is subdivided in two results – the dirt particle area larger than 50 µm particle diameter, which represents all particles visible with the naked eye, and the area of particles above 250 µm diameter. This is very close to the TAPPI assessment of dirt specks which counts all spots above 225 µm. Additionally, the color shade on the red-green axis of the deinked pulp is determined by a*. This is due to the fact that the red discoloration is more critical than a discoloration on the yellow-blue axis (b*). The two other parameters are process parameters (ink elimination IE, discoloration of the filtrate ΔY) describing possible effects of ink carry-over on the deinking process. In the assessment, they complement the information provided by the three quality parameters.

The test results are converted to a score system [4, 5]. This allows expressing the deinkability assessment in one figure by weighing the parameters according to their importance. Additionally, the Deinkability Scores provide the opportunity to compare different product categories. The maximum score is 100 in all product categories together.

To achieve a common score system, threshold as well as target values are defined. Depending on the type of threshold values a lower threshold, an upper threshold or a threshold corridor is defined which has to be exceeded, undercut or met. These threshold values do not depend on the print product category. For a given print product, threshold values have to be fulfilled for all parameters. If one or more thresholds are not met, a print product is rated to be "not suitable for deinking". This does not exclude that it can be used for other ways of recycling such as board manufacturing or thermal use.

Target values are set for each group of print products and for each parameter. The target values of the parameters color (a*; green-red axis), dirt particle area (A50 and A250) and filtrate darkening (ΔY) are equal for each print product category. The target values of the luminosity of the deinked pulp (Y) and the ink elimination (IE) have variable levels depending on the print product category.

If the target value of a parameter is met, the full score is given for this parameter. The maximum scores of the individual parameters are different in order to reflect their importance. The luminosity of the deinked pulp has, with a proportion of 35%, the most significant effect on the total Deinkability Score, followed by dirt particle areas (25% as total of A50 and A250) and color (20 %) of the deinked pulp and the two process parameters ink elimination and filtrate darkening (10% each).

Between the threshold and the target value of each parameter, the score is linearly subdivided, resulting in a constant increment per parameter. Finally, the score of all five parameters is added up to provide a single number that corresponds to the total score for a particular print. This allows a simple overall assessment on the deinkability of a print product with one numerical value between 0 and 100 points comparable to test results of consumer goods. If one or more threshold value fails, the print product is considered unsuitable for deinking. Anyhow, the product may be well recyclable without deinking – for example in a board mill. If all thresholds are reached the product is judged to be deinkable with three various gradations: poor, fair and good.

Rating of the Deinkability Scores

Score	Evaluation of deinkability
71 to 100 Points	Good
51 to 70 Points	Fair
0 to 50 Points	Poor
negative (failed to meet at least one threshold)	Not suitable for deinking

Deinkability Test Results – Overview

Since the scoring system has been developed, European research institutes have performed more than 300 deinkability tests on behalf of INGEDE. Each stacked column in Figure 1 represents the average score of this product category. The columns are subdivided in the individual scores for the different assessment parameters. The figures above the columns indicate the number of test results in each category and the share of positive results.

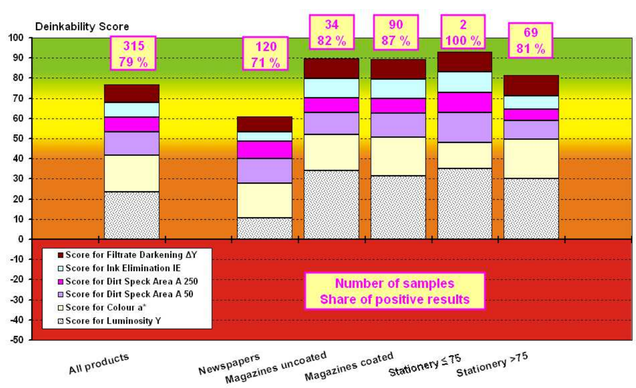

***Figure 1**. Deinkability Scores: Results in Benchmarking Categories*

The category "Newspapers" contains also results of flyers if they are printed on newsprint paper and of telephone directories. It mainly consists of offset products. Some of the prints are waterbased flexographic prints and the group contains also some inkjet newspapers which had been presented on exhibitions and trade shows. Letterpress doesn't have any more significance on the European newspaper market. 71% of the tested samples have a positive deinkability result.

81% of the offset prints – mainly newspapers and magazines – achieved a positive assessment of their deinkability. If they fail, it is usually due to luminosity or dirt particle area. The latter often occurs in case of UV cured prints. Luminosity deficits are in connection with high amount of inks on low weight paper, e. g. with tabloid newspapers and promotional flyers. Waterless offset was found to be rather trouble free.

Rotogravure prints are generally good deinkable. The few ones which failed were due to dirt particles. Red discoloration is sometimes visible but in no case lead to a negative assessment. This is an improvement compared to older results.

All tests with flexographic prints failed in luminosity, ink elimination and filtrate darkening due to the hydrophilic nature of the ink particles. Research has shown that newly developed inks can perform better in the deinking plants but these are not yet established commercially. In a few cases the deinking process can be tuned a little to cope better with flexo, but usually at the expense of a lower efficiency in the removal of other ink types present in the furnish.

In these conventional printing technologies, the variations in the deinkability are more pronounced with uncoated papers.

Toner prints are usually well deinkable if they are made with a dry toner process. All samples of liquid toner prints fail a positive judgment because of a very high content of dirt particles in the deinked pulp. The toner films are very cohesive and flexible; they do not fragment well enough during pulping.

Inkjet prints in most cases fail to achieve a positive deinkability result. Most of the samples investigated were inkjet printed newspapers which are nowadays promoted for small volumes and remote locations, e. g. foreign newspapers at international airports. Similar to flexographic prints, inkjet fail due to luminosity, ink elimination and filtrate darkening.

With the predicted growth rates for inkjet and with the current state of its deinkability, this printing technology represents a real challenge for deinking mills. An intensive dialogue with the OEMs for inkjet systems is one of the major activities of INGEDE currently. There are some indicators how the deinkability can be improved. An agglomeration or precipitation of pigment based inks at the paper surface seems to be a promising solution. This requires a surface preparation of the paper, either on the paper machine or prior to the contact with ink in the printing machine.

Testing Digital Prints – Recent Results

The poor deinkability of some digital prints has been identified early as a possible threat to today's paper recycling systems: Although some of these prints deink quite easily, others lead to significant discoloration of the circulation water or to a high load of dirt specks. This observation is reflected by including deinkability as a necessary feature into some eco-labels already [6].

INGEDE cooperates with printer manufacturers for testing but also takes field samples to look into their deinkability as an important feature of the overall life cycle of a printed product.

Frequent testing also allows observing trends in recent developments of printers and inks. Together with manufacturers, the development can be optimized to match also the requirements of proper processing of a printed product after its use.

Already at drupa, a concept of precipitating pigmented inkjet inks has been shown by HP and was found to be good deinkable. In the meantime this concept has been altered by HP so the current products do not pass tests according to INGEDE Method 11 any more. A similar concept has been introduced by Fujifilm for IPEX 2010. Here the implementation leads to good deinkability. Details will be presented.

Another concept to achieve good deinkability is to avoid aqueous systems at all. At IPEX 2010, Xerox demonstrated a prototype of jetting a molten polymer rather than an aqueous ink solution. This approach looks to be independent from the paper used.

Still the paper can have an enormous influence on the deinkability. Some bonding agent systems seem to work on uncoated paper only; others are used only on coated paper. Special paper coatings to improve image quality for inkjet prints can also lead to declined deinkability, while one special paper seems to significantly improve the deinkability even of many dye based inks.

References

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Axel Fischer studied chemistry at Munich Technical University. He worked as a Science Writer for TV, print media and Germany's major news agency. Now he works as communications consultant for the chemical industry and the paper industry. Since 1994, he is responsible for the public relations of INGEDE, the International Association of the Deinking Industry. He chairs the "Digital Round Table", a forum initiated by INGEDE to improve the Deinkability of Digital Prints.