Deinking of Recovered Paper Mixtures Containing Digital Prints - Challenges and Prospects

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Abstract

Deinkability of a print product is evaluated today typically according to the ERPC "Assessment of Print Product Recyclability – Deinkability Score". For the manufacturer of print products it is relevant and useful to know the deinkability behavior of "his" single product. But paper mills never have to deink one specific print product; they have to handle a recovered paper mixture. This mixture consists of the large volumes of products printed mainly in offset and rotogravure on various paper grades. Nowadays increasing amounts of digital prints from private households and offices are parts of the recovered paper mix.

Operation conditions of a paper mill have to be oriented on the deinking result of the recovered paper mix. Therefore, the paper demonstrates the impact of various digital prints (inkjet, dry and liquid toner) as a portion of the recovered paper mixture showing its behavior during deinking. Different mixtures of digital prints in recovered paper are investigated by flotation deinking under variation of deinking chemistry and bleaching conditions. The effects on optical characteristics of the deinked pulp as well as on process parameters are shown.

Background

Recovered paper is Germany´s most important fiber resource and represents 70 % of the total fiber raw material of the German paper industry in 2010 [1]. Recyclability is a key aspect for the high usage of recovered paper, because only with a good recyclability it is possible to enhance the usage of recovered paper as raw material for paper products of higher quality. Therefore it is necessary to design recycling friendly products to enhance the recyclability and the usage of recovered paper. Nevertheless recovered paper as raw material saves energy and natural resources. To evaluate the deinkability, the evaluation of optical characteristics is necessary and is done by a simulated deinking process.

The INGEDE Method 11p [2] simulates a typical one loop deinking process with disintegration and flotation, using standard deinking chemicals and typical conditions of a paper mill. Therefore it is possible to evaluate and compare the behavior of different print products by the same process. For digital prints, products printed with liquid toner (LEP), inkjet as newsprint or stationery products (with pigment or dye based printing inks) and dry toner are often evaluated. But, by definition of the ERPC Deinkability Score, only the single print product with its specific printing technology and ink-paper combination are evaluated.

The question is how these different printing products behave during an industrial deinking process, where a mixture of digital prints and standard prints are used.

Experimental Setup

The impact of difficult to deink paper grades on DIP quality of a standard recovered paper mixture is investigated. The standard mixture is defined as 50 % offset newspaper, 30 % coated offset magazines and 20 % coated rotogravure magazines. For the digital mixtures offset newspaper is substituted by inkjet newspaper and rotogravure, as well as offset LWC magazines by LEP/inkjet stationery or dry toner prints. Each print product was investigated in a 100 % test for having a reference to the common evaluation. Achieving a measureable effect the influence of 30 % digital prints on standard print products was investigated. As inkjet newspaper a commercial colored newspaper on standard newsprint was used. For the liquid toner prints commercial photo prints, which had been printed both sides, were added. For the dry toner the colored INGEDE test sheet was used, which was printed both sides on standard woodfree office paper, as well as for the inkjet stationery sample. The inkjet composition for these sheets was pigment based for the black ink and dye based for the colored ink. The composition of the different mixtures is presented in Table 1.

Table 1: Composition of print products mixtures

Print Product		K1	K2	K3	K4	K5	K6	K7	K8	K10	K12	K14	K16
Offset Newspaper	%	100			50					20	50	50	50
Offset LWC Magazine	%		100		30					30	15	15	15
Rotograv. LWC Magazine	%			100	20					20	5	5	5
Inkjet Newspaper	%					100				30			
LEP Prints	%						100				30		
Dry Toner Prints	%							100				30	
Inkjet Stationery	%								100				30

In the following figures the recovered paper mixtures K10, K12, K14 and K16 are named as “Inkjet NP Mix 30”, “LEP Mix 30”, “Dry Toner Mix 30” and “Inkjet Stat. Mix 30”. In a special trial different contents of LEP have been added to a standard mixture, the influence on dirt particles have been investigated.

Figure 1 gives a brief overview of the used lab procedure. There are some changes to the original INGEDE Method 11p [2]: A fix dosage of standard deinking chemistry is used, which means that the pH value is not corrected. Only the influence and implied changes by the different raw material mixtures are investigated. As an alternative, 0.6 % of special deinking chemistry (surfactant A) was added in several trails during pulping. The possibility of improving deinking results by using such chemicals has been reported [3]. The disintegration was done at high consistency in a Hobart device. Flotation was performed in a Voith Flotation cell. Also during flotation, the usage of a special deinking chemistry (0.05 % of surfactant B) was investigated in several trials. This application has also been mentioned in literature [3]. For all trials handsheets of undeinked pulp (UP) and deinked pulp (DP) were generated for dirt particle measurement.

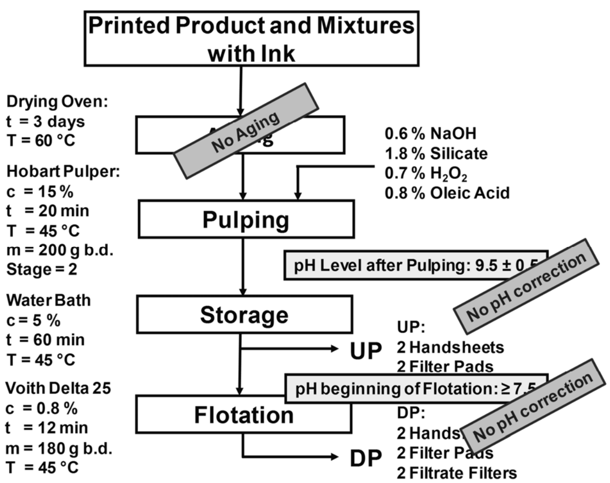

Figure 1. Changes in deinking procedure based on INGEDE Method 11p [2]

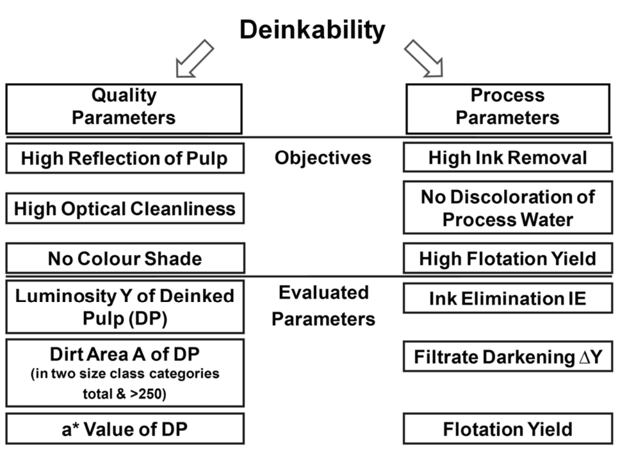

Figure 2. Objectives and evaluated parameters for deinkability assessment

In the special case of inkjet prints with dye based inks bleaching is also a widely known method to improve optical characteristics (mainly luminosity Y and color value a*). This is only meaningful for digital prints with dye based inkjet, because pigments could not be bleached. As a reference the standard mixture was also bleached. The bleaching was done after a deinking process with standard chemistry. As bleaching conditions 0.7 % and 1.5 % peroxide were used as a oxidative process with 2 % silicate and 0.3 %, resp. 0.6 % sodium hydroxide. The stock consistency during the trials was 15 %. The bleaching lasted for 90 min at a temperature of 60° C.

After all tests DIP quality and process parameters are measured according to Figure 2. A key aspect is that deinkability scores are not evaluated and just the results of the various parameters are compared.

The interesting part is how changes in the raw material mixture effects the results in relation to the standard raw material used. Therefore it is helpful to scale all the results based on same relationship and get a view about the effect, which leads to the definition of the Influence Ratio:

Results of Trial with Standard Mix /
Results of Trial with Digital Print = Influence Ratio (1)

The Influence Ratio describes the results of the standard mixture in relation to the results of a trial with digital prints. If the ratio is higher than one, the so called digital results are lower than for the standard mixture. The ratio can be lower than one, meaning a higher result than for the standard mixture. The influence for ach parameter can be distinguished. This is essential, as sometimes a lower result for a special parameter may be positive (e.g. meaning a lower dirt particle area), but sometimes negative, e.g. a lower flotation yield.

Results

Different Mixtures

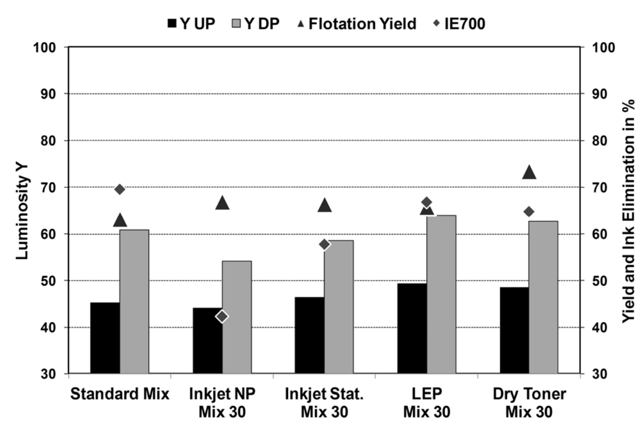

Figure 3. Luminosity, ink elimination and yield for mixtures

Figure 3 shows the results of the different raw material compositions. On the left side the standard mixture as reference is plotted. The addition of inkjet, even as stationery, leads to lower results for the luminosity Y despite the used woodfree office paper. This is due to the finely dispersed ink particles. It also influences the ink elimination IE. The influence on flotation yield seems to be low. For toner prints a higher luminosity Y is observed, but how react other parameters?

The results of the mixtures are printed as Influence Ratio for the luminosity Y, ink elimination IE and flotation yield in Figure 4. As a ratio greater than one is equivalent to poorer results with the digital mixture than for the standard mixture results, this is conform to a negative influence. The addition of digital prints slightly influences the luminosity Y and flotation yield. For the luminosity Y, inkjet is challenging, because the ink elimination IE is influenced clearly in a negative way.

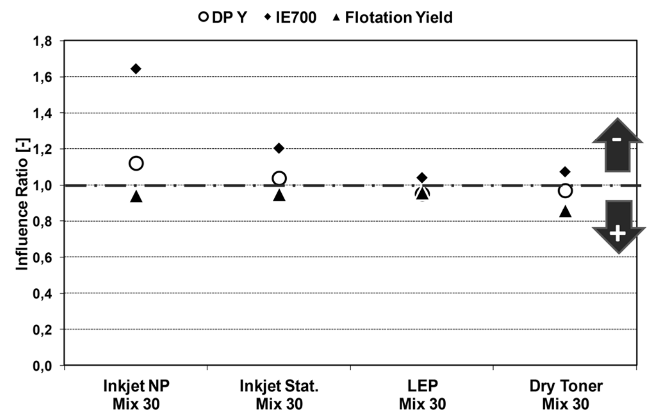

***Figure 4**. Influence Ratio of luminosity, ink elimination and yield for mixtures*

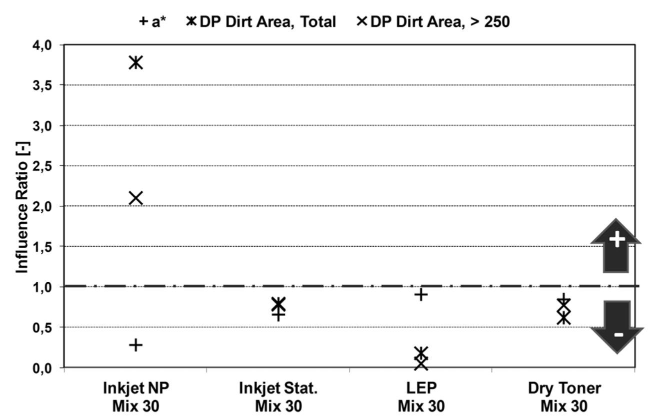

***Figure 5**. Influence Ratio of color value and dirt particle area for mixtures*

If the Influence Ratio for the color value a* and dirt particle area A is analyzed as visible in Figure 5, the judgment has to be changed as poorer results in relation to the standard mixture correspond to a positive effect. Therefore the results greater than one are positive, lower than one are negative. It is very clear, that the addition of inkjet material can improve the dirt particle are (as the ink forms very small particles), but as matter of fact, this impairs negatively the color value a* as well. This might be compensated by a bleaching step.

For toner prints, the picture is totally different. Whilst the dirt particle area A is influenced in a negative way, there is only a very slight influence on the color value a*. Maybe this might be changed by changing the deinking chemistry.

Different flotation chemistry

As the special chemistry is developed for changing the dirt particle area A, the overall results for the total dirt particles area A of the trials with 100 % of LEP and 30 % of LEP in a mixture, in combination with the results according to standard chemistry, are presented in Figure 6.

It comes clear that there is a dirt particle reduction, but for the 100 % trial the results with special chemistry after the flotation process are still high with an area of 3 000 mm²/m². The dosage of the special chemistry recently showed better results for the dirt particles area A [3]. Anyhow, the chemical dosage seems to be sufficient for the trial with a 30 % mixture, as the dirt particle area A in the deinked pulp is lower (~ 600 mm²/m²). So the optimum dosage of the chemistry is dependent on the content of these print products in the mixture.

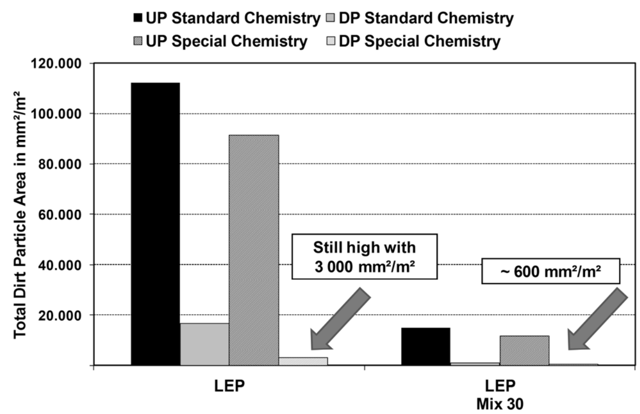

***Figure 6**. Dirt particle area A of toner prints deinked with special chemistry*

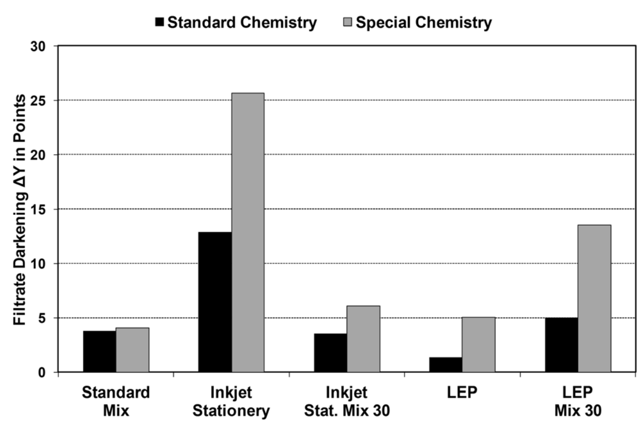

***Figure 7**. Influence of special chemistry on filtrate darkening ΔY*

Comparing other parameters for the special deinking chemistry, an influence on luminosity Y, ink elimination IE and flotation yield is only in a minor way visible, but with a negative tendency. The special chemistry mainly influences dirt particle reduction. The influence of the chemistry on filtrate darkening ΔY is outstanding as printed in Figure 7. Also for this special chemistry there is a clear increase of filtrate darkening ΔY for the trails with LEP toner noticeable. This effect is surprising and should be investigated further on. But generally, the special chemistry nearly doubles the filtrate darkening values for most of the investigated digital prints. Hence more research is necessary to explain this.

Influence of increasing contents of LEP

Figure 8 shows the development of dirt particle area of the deinked pulp with increasing contents of LEP in the standard mixture. As visible, the content of LEP should not exceed a certain level, as increasing contents increase the dirt particle area. This increase can be described by an exponential function. Alike, small contents of LEP show no great effect in this laboratory investigation.

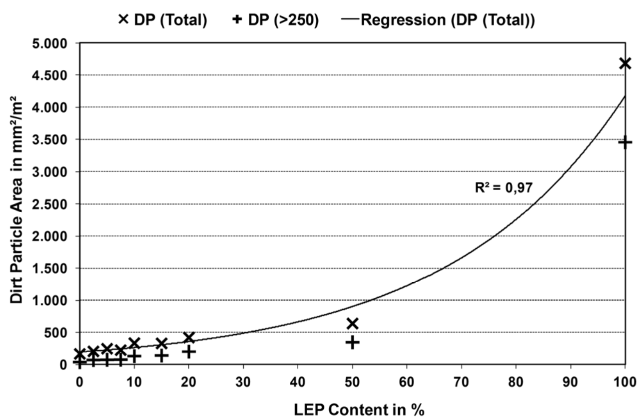

***Figure 8**. Influence of increased contents of LEP on standard mixture deinked with standard chemistry*

Bleaching Potential

Bleaching can be used to improve optical characteristics as luminosity Y or the color value a*.

The highest increase of luminosity is possible for the standard mixture, for the inkjet mixture the increase is a bit lower. The maximum bleaching potential is about 2 - 2.5 luminosity points with a peroxide dosage of 0.7 %. There is no positive influence on the color value a*, therefore a reductive bleaching seems to be necessary to change discoloration. A maximum luminosity for inkjet mixture containing inkjet newspaper is close to a luminosity of 57, a luminosity of 61 is possible for a mixture containing inkjet stationery and 63 for the standard mix.

Conclusion

The mixtures of different raw materials lead to modified deinking results than gained by the single print products. By mixing raw materials some parameters of the flotation process are influenced positive, some negative. This depends on what product is substituted.

As the results of the different digital prints vary very strongly and within a wide range, the evaluation is challenging, as no scoring for benchmarking or no estimation of the results is possible. A calculation is not possible and real investigations are necessary. The existing scoring is not useful, as no product categories for recovered paper mixtures are available.

The addition of digital prints to a standard recovered paper mixture means a changing of flotation results depending on the added print product.

For inkjet products (newspaper and stationery products) a lower luminosity Y and lower dirt particle area A can be estimated. But also lower color values a* (< -3) and higher filtrate darkening ΔY can be discovered.

If toner material is added to a paper mixture, for example as liquid toner or dry toner, a higher luminosity Y of the deinked pulp can be assumed, but also a higher ash content and higher dirt particle area A.

All the results are depending on the added proportion of several print products.

Changing the deinking chemistry leads generally to a slight decrease in luminosity Y and flotation yield, a minor increase in ink elimination IE and a better dirt particles reduction is possible. A negative influence on filtrate darkening ΔY is visible for almost all investigated products and mixtures.

The addition of a bleaching step can increase the luminosity Y for a maximum of 2.5 points with a dosage of 0.7 % peroxide. But there is no positive effect on the color value a*, an improvement is still necessary. Perhaps an additional reductive bleaching step could be beneficial.

References

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[2] N. N.: Assesment of Print Product Recyclability – Deinkability test. INGEDE Method 11p, Draft 12/2009, http://www.ingede.de/ingindxe/methods/ingede-method11p-2009.pdf

[3] Ng, H. T., Bhattacharyya, M. K., Mittelstadt, L. and Hanson, E., Deinking and Recycling HP Digital Inks: From Lab Scale to Pilot Scale. TAPPI Peers Conference and 9th Research Forum on Recycling, 18.10. - 20.10.2010, Norfolk (VA) USA.

Author Biography

Dennis Voss is a member of the research staff at the chair of paper technology at Technische Universität Darmstadt, Darmstadt in Germany. His main field of work is about paper recycling in general, dealing with several topics about separation technologies, impurities evaluation and different deinking developments.

He graduated as graduate engineer about paper science in 2009. Afterwards he started his Ph.D. about deinking of water based inks from recovered paper, which he currently finished.