Attempts to Improve the Deinkability of Ink jet Inks

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Abstract

Deinkability of inkjet printed waste papers was assessed by flotation deinking method with fatty alcohol derivative as a deinking agent. Though inkjet inks are easily detached from the waste paper, detached inks are too small to be rejected out in the flotation cell. In order to increase the flotation efficiency, the kneading process was omitted and fatty acid or new ink collector was added in the flotation cell. Consequently, the brightness of the deinked pulp sheet obtained after flotation increased markedly. From these results, when the collected waste papers are only inkjet printings, inkjet inks are said to be deinkable by the current deinking line. But practically, waste papers are mixtures of digital and offset printings, since they are not classified by their printing types. When the electrophotography printed waste papers are deinked, strong shearing power is needed, consequently kneading cannot be avoided. It is necessary to establish the deinking method and develop the deinking agents and/or systems for mixed on-demand printings in early stage.

Introduction

Japanese paper and paperboard production in 2009 was about 26 million tons. Though the production in 2009 decreased because of Lehman shock, 10-year production average has been around 30 million tons. However, the content of the pulp used in this production has changed every year. The amount of recycled pulp has been gradually increasing and reached a world-class utilization rate of 63 percent last year. As a background note, it can be said that the waste paper collection system and excellent technologies to remove foreign particles and inks from waste papers are well-established in Japan.

There are two methods when waste papers are recycled. One is using recycled pulp as it is after pulping to make cardboard and other materials. The other method involves removing the ink from the recycled pulp after pulping to make printing paper, tissue paper and other materials. This treatment is called “deinking”. If the ink and paper are regarded as soil and clothing respectively, “deinking” is analogous to “washing” in the household laundry process. So, “deinking” can be described as “the washing of waste paper”. A point of difference between deinking and the laundry washing process is that papers are disintegrated to pulp fibers during the deinking process. A point of similarity is that both processes make use of surfactants and alkali. Specialized surfactants used in the deinking process are known as “deinking agents”.

The number of digital prints produced by commercial electrophotography and inkjet are expected to continue to increase in the market rapidly in the near future. This means waste papers printed by these printing methods will be collected as furnishes for paper making. The deinking process established at the present time is one for recycling of waste newspapers and inserts. It is now necessary to recognize the deinkability of these digital printings and establish the appropriate deinking method for them. For deinking of such printings, it is necessary to note:

1. These digital printings must be deinked by the conventional deinking process.
2. As these digital printings and offset printings can not be classified in collection, mixed wastes must be deinked.

In this presentation, the problems encountered in the deinking of inkjet printed wastes by conventional deinking method will be informed.

Deinking of waste newspaper

Deinking consists of two main processes. One is the process of ink detaching from pulp and the other is the process of ink rejecting out of the system. For rejecting inks out of the system, flotation and washing are the two processes used today. The flotation method shown in Figure 1 is the main process used in the industry currently.

1. Ink detachment

In the ink detaching process, deinking agent and sodium hydroxide are added to high consistency (5 -15 wt.%) pulp slurry in the pulper, and inks are detached from pulp fibers with mechanical force. Typical surfactants used as deinking agents are fatty alcohol derivatives, fatty oil derivatives, fatty acid derivatives and fatty acids as shown in Figure 2. As printing methods for newspapers have been changed from relief printing to offset printing, it becomes difficult to detach inks from the pulp fibers. As a result, deinking mills have installed kneaders to give the pulp fibers stronger shearing force and have been using fatty alcohol derivatives as deinking agents which have higher surface activity. As a result of these process changes, about 95% of the inks that exist in the waste newspaper are able to be detached now. The problem that deinking mills face now in their effort to obtain higher quality deinked pulp is the removal of these detached inks from the final deinked pulp. Some of these ink particles are too small to be rejected out in the flotation process.

2. Ink rejection in the flotation process

Before flotation, the pulp slurry is diluted to about 1 wt.%. In the flotation process, ink particles that are less than 4um are not easily rejected. The brightness of the pulp after flotation decreases greatly when even small amounts of fine ink particles (<4um) remain. So in the flotation process, deinking agents are required to coagulate fine ink particles to a size greater than 4um and to adsorb the coagulated inks on the bubble surface. Therefore, deinking agents must be designed to show higher surface activity

in the ink detaching process and lower surface activity in the flotation (ink rejecting) process.

Here, the reason why detached inks must be rejected out more in the flotation process and not in the washing process is described. In the deinking mill, 100 times as much process water as pulp is used and circulated as shown in Figure 1. Ink not rejected in the flotation process can be rejected in the washing process. But, this post-washing process water (which contains fine ink particles) will be used as diluting water in the flotation process. Consequently, unrejected inks in the flotation process will remain in the deinking systems and accumulate, so that the deinked pulp quality will gradually decrease. This is the reason why detached inks must be rejected out in the flotation.

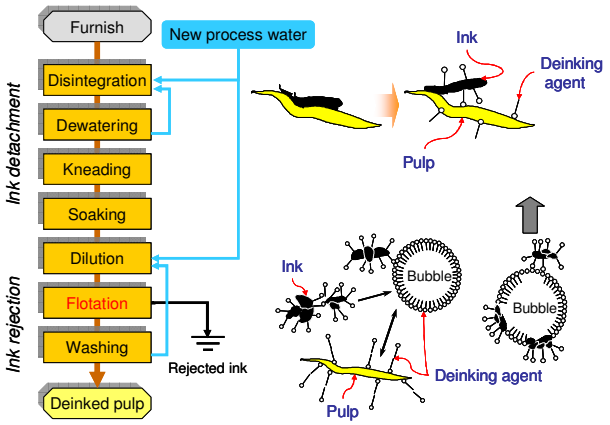

Figure 1. *Flotation deinking process*

In the present deinking agents, fatty acid is an excellent ink coagulant. Fatty acid has moderate surface activity and forms calcium soap scum so that detached inks coagulate around the scum and grow to more than 4um. Unfortunately, fatty acid does not have strong ink detaching abilities, so it is not used by itself in Japan mills. For higher quality deinked pulp in which inks are properly detached and rejected, the combination of fatty alcohol derivatives in the pulper and fatty acid in the flotation has been adopted.

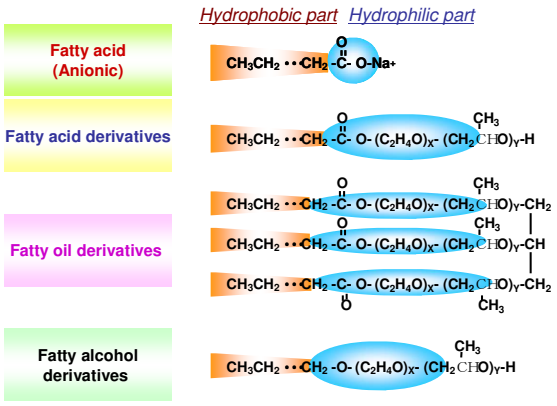

Figure 2. *Typical deinking agent*

Experimental

Printings

Printings of the same articles printed by electrophotography (FUJI XEROX DocuCentre Color f450) or inkjet (RICOH GX5000) were used as furnishes. In inkjet printing, three kinds of pigment inks were examined: a self-dispersed type, just polymer-dispersed type and Kao's encapsulated type (ink A and B). Re-dispersibility of ink B is inferior to that of ink A.

Xerox 4200 and ColorLok were used as base papers.

When the effect of primer was examined, Canon MX7600 was used as the printer.

As a reference, waste newspaper and insert (60/40) was deinked by using the same process and the same deinking agent.

Deinking method

Figure 3 shows the lab test flow which is the typical deinking process for waste newspaper in Japan. DI-7250 was used as a deinking agent. DI-7250 is a typical Kao fatty alcohol derivative.

In order to increase flotation efficiency, either fatty acid or DI-3000 (Kao's special ink collector) was added to the kneader as necessary. "PC" in Figure 3 denotes pulp concentration.

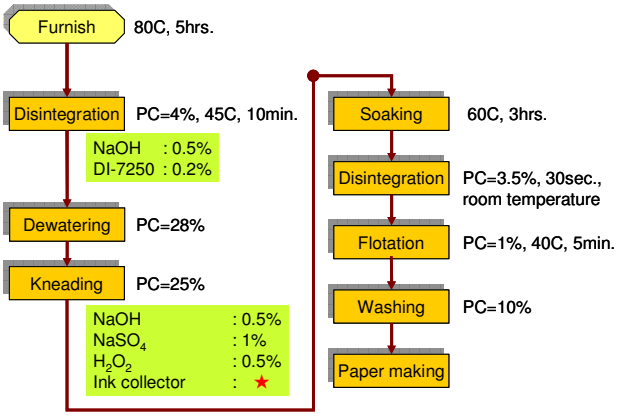

Figure 3. *Deinking test flow*

Results and Discussion

1. Deinkability of Inkjet Printed Printing

In Figure 4, the deinked pulp sheets obtained after flotation are shown. The numbers in the figure denote the brightness of the sheets. As the brightness of Xerox 4200 paper is 94.5, the deinkability of inkjet printings is easily understood to be bad. In inkjet printings, printings printed by Kao's ink A showed the best deinkability. Electrophotography printed papers can be said to be completely deinkable.

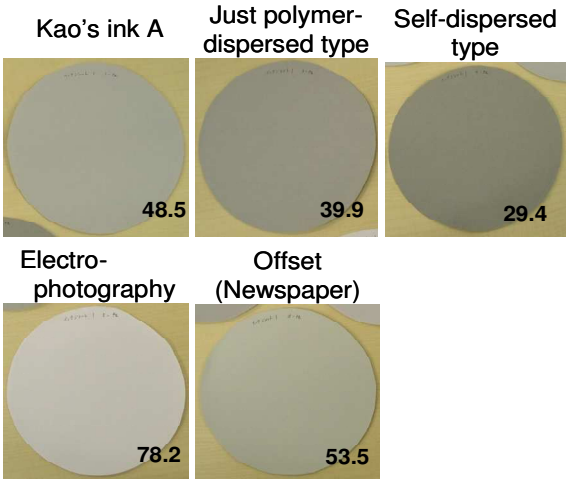

Figure 4. *Brightness after flotation, Xerox4200 was used as base paper*

(1)

Figure 5 shows the brightness of the completely washed pulp sheet which was obtained after the ink detaching process. When(2) this sheet was obtained, the pulp slurry was washed by volumes of(3) water disregarding the pulp yield. By using this treatment, the(4) reason why brightness doesn't go up can be understood whether it is due to poor ink detachment or due to poor ink rejection in the flotation.

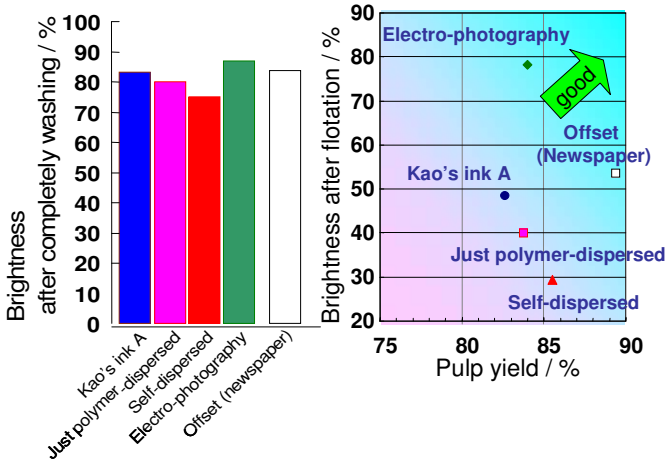

Figure 5(left). *Brightness of completely washed pulp*
Figure 6(right). *Brightness and Pulp yield in flotation*

As Figure 5 shows, in case of electrophotography printings, ink (toner) can be almost completely detached from the fibers. In case of inkjet printings, although the results are a little inferior compared with electrophotography printings, without question it can be said that the ink is detached. However, in the case of inkjet printings printed by dispersed ink and self-dispersed ink, inks soak into the pulp and the resulting deinked pulp sheets are dull.

From these results, the poorer brightness gain observed in the deinking of inkjet printings is attributed to insufficient ink rejection in the flotation process and not to inadequate ink detachment during the pulping process . It is possible to improve the brightness if the foam volume (the pulp loss) in the flotation is increased. As shown in Figure 6, however, this approach cannot be adopted because the pulp yield is already about 85% and it cannot be hoped for brightness improvement judging from the relationship between brightness and pulp yield.

Why cannot inkjet inks be rejected in the flotation? Figure 7 shows the brightness of pulp sheets in each deinking process. All kind of inkjet inks are rejected in washing process. Especially, the brightness of the sheet printed by Kao's ink reached to around 70% after washing, so even ink particles with size below 4um can be rejected in washing process. Inkjet inks can be almost completely detached from the fiber as mentioned before, but some ink particles are too small to be rejected out in flotation. Judging from the relative size difference between ink particles and electrophotography (toner) particles, these deinking results are not surprising.

Are there any methods by which the flotation efficiency can be increased? At present, the following ideas are cited.

Change the dispersant of colorant (Kao ink B) which can interact with each other to coagulate pigments.

Combine other chemicals like primers.

Select the treated paper.

Use ink collector in the flotation..

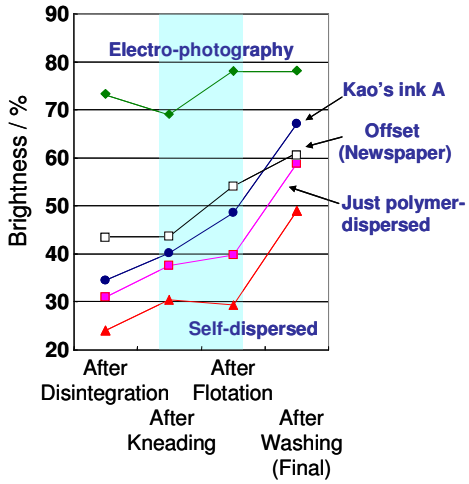

Figure 7. *Brightness in each process*

2. Improvement of Inkjet Printed Printing's Deinkability

Deinkability of inkjet printings which are obtained by changing dispersant of colorant (ink B), selecting the treated paper and combining a primer together was examined. Results are shown in Figure 8.

Though the brightness level is not satisfactory, deinkability of inkjet ink B was slightly better than that of ink A regardless of the kind of paper or the presence of the primer. Primer treatment was effective for Kao inks (A and B), but was not for self-dispersed type and just polymer-dispersed type.

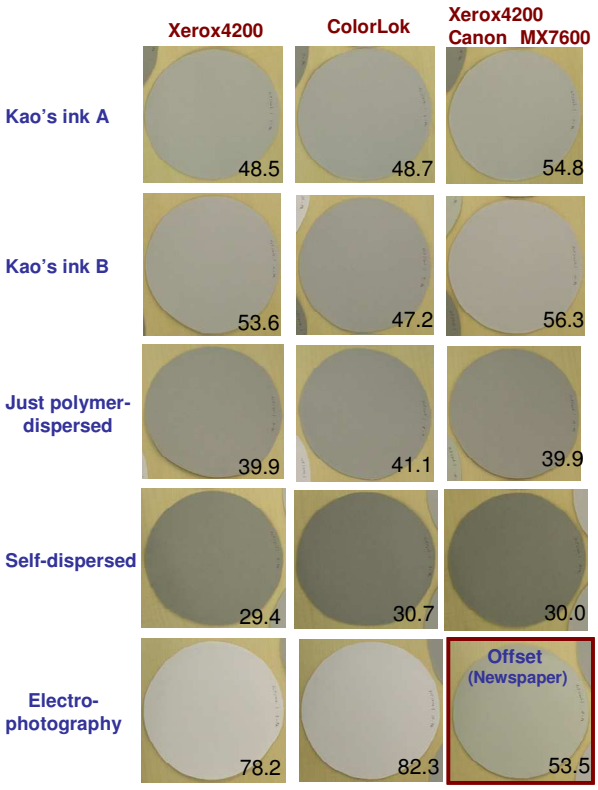

Figure 8. *Brightness after flotation*

To deteriorate re-dispersibility of ink (ink B) leads to an increase in the coagulating power of ink. So, the flotation efficiency is increased by this approach. But, from the standpoint of inkjet ink performance, this ink (ink B) is not good for inkjet printer. It is necessary to design new encapsulating polymers and/or ideas to coagulate inks on media. Primer treatment is thought to be one of the candidates. Though the reason why primer treatment was effective for Kao ink is not clear yet, it is necessary to design new inkjet inks suitable for primers and new primers suitable for inks for the deinking of inkjet printings.

As mentioned before, some fraction of the inkjet ink particles is too small to be rejected out in the flotation process. In the same case of newsprint deinking, fatty acid is often used as an ink collector.

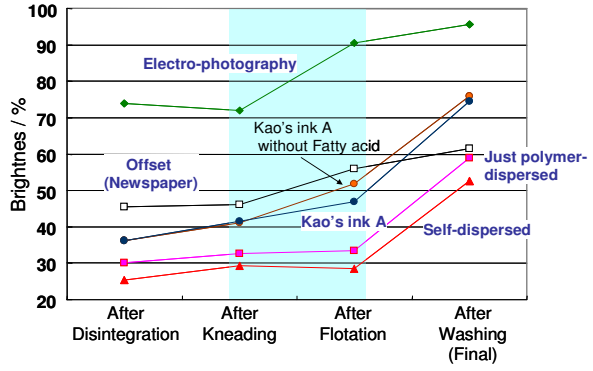

Figure 9. *Effect of Fatty acid*

Also in this study, fatty acid was added in the flotation process. Unfortunately, no benefit was observed and the combination of fatty acid decreased the brightness of the sheet obtained after flotation (Figure 9). The reason of this effect is not clear.

Kao has an ink collector called DI-3000 of which the ink collecting mechanism is different from that of fatty acid. The deinkability of Kao's ink using DI-3000 as a collector instead of fatty acid was studied and the results are shown in Figure 10. Unfortunately, no improvements in flotation efficiency were observed with this collector. But no loss in flotation brightness was observed either.

Strong shearing power is thought to make ink particles finer. So, the deinkability of Kao's ink was examined by an improved deinking method using low shearing power (no kneading) and the combination of either fatty acid or DI-3000 (Figure 10). In this method, improvements were observed with both fatty acid and DI-3000. Especially, the brightness of the sheet obtained after flotation with DI-3000 exceeded 60%. Although only inkjet printings printed by Kao's ink were checked this time, from this improved method, it can be said that there is some possibility to deink only inkjet printed waste papers with conventional flotation deinking process with ink collectors.

Strong shearing power is needed when electrophotography printed wastes are deinked. Deinkability of electrophotography printings was not checked yet under above-mentioned improved method. From now on, it is necessary to establish the adequate shearing power and dosage of ink collector for the deinking of mixed wastes of electrophotography and inkjet printings.

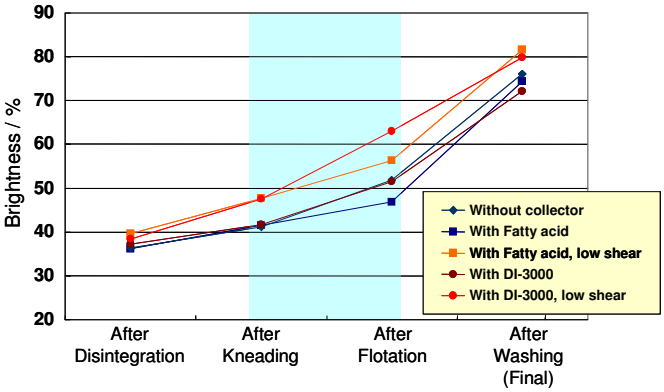

Figure 10. *Effect of Fatty acid and DI-3000*

Conclusion

1. Deinkability of inkjet inks was assessed by flotation deinking method with fatty alcohol derivative as a deinking agent.

* Inks are easily detached from the waste paper.

* Some fraction of the detached inks is too small to be rejected out in the flotation cell.

(Brightness gain is observed in the washing process.)

* At present, Kao's encapsulated inkjet ink shows the best deinkability.

2. In order to increase the ink size in the flotation, the effects of changing the dispersant of colorant (ink B), printing pre-treated paper and combining with primer were examined.

* More hydrophobic ink showed better deinkability.

* Primer treatment is effective.
* But, these actions don't have reached the goal.

2. In order to increase the flotation efficiency, the kneading process was omitted and fatty acid or ink collector, DI-3000, was added in the flotation cell.

* The brightness of the deinked pulp obtained after flotation increased markedly.
* When the collected waste papers are only inkjet printings, they are said to be deinkable by the current deinking line if ink collectors are used.

3. Practically, waste papers are mixtures of digital and offset printings since they are not classified by their printing types. And strong ink detaching power is needed (i.e. kneading can not be avoided) when waste papers printed by electrophotography are deinked.

* It is necessary to establish the deinking method for mixed on-demand printings and develop the inkjet ink which is deinkable (by Kao).

References

[1] H. Takahashi, Japanese Journal of Paper Technology, 1, (5) P.1 (1997)
[2] Y. Irinatsu, Japanese Journal of Paper Technology, 44, (6) P.53 (2001)
[3] Y. Irinatsu, Japan TAPPI Journal, 56, (7) P.30 (2002)

Author Biography

In 1982, Hiromichi Takahashi graduated from Kyoto University, faculty of science and joined Kao Corporation. From 1982 to now, He has been developing shampoos, deinking agents for waste paper recycling, bulking promoters for paper thickness, superplasticizers for concrete and colorants and inks for ink jet printer. He is the manager of Global R&D - Performance Chemicals.

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