

Novel Kaolin-Based Deinking Reagent For Improved Deinking of Waste Paper

Cesar Basilio

ABSTRACT

A novel deinking reagent based on modified kaolin has been developed for the flotation deinking of waste paper. This deinking reagent, called DEKA 2000, is composed of the modified kaolin and a surfactant specifically formulated to maximize the effect of this modified kaolin in flotation deinking. As is well known in the literature, the very fine particle size of ink, dirt, and stickies particles is one of the main causes for their poor floatability in flotation deinking. However, due to the hydrophobicity and relatively larger particle size of the modified kaolin, this deinking reagent acts as a collector for these fine particles. Thus, this deinking reagent gives more efficient separation and removal of the ink, dirt, and stickies particles from the waste papers being recycled. Deinking mills using this novel deinking reagent showed an increase in brightness and lower dirt count values of the deinked pulp. In addition, lower stickies content were observed in the deinked pulp, resulting in better runnability of the paper machine. In some cases, the use of this deinking reagent has allowed the deinking mill to use poorer grade of feed furnish. Overall, the results obtained by deinking mills show that the use of DEKA 2000 can improve brightness, lower dirt count values, improve stickies removal, and reduce total cost.

Introduction

Deinked pulp (DIP) from waste paper such as old newspaper (ONP), old magazine (OMG), and mixed office waste (MOW) has become a principal source of raw material for making paper in the US and Europe, with significant growth in China and other Asian countries (1). In India, the share of waste paper used as raw material for the paper industry is about 47% (2). Many newsprint, tissue, and paperboard grades are made from 100% deinked pulp while a number of other grades of paper, such as lightweight-coated paper, now contain a significant amount of DIP. The deinking process has evolved throughout the years to provide for the effective removal of ink from waste paper. Deinking is typically carried out by converting the waste paper to a pulp and then separating the ink particles and other impurities from the pulp fiber.

In flotation deinking, the most common types of surfactants used are either fatty acid soaps, non-ionic surfactants such as alkoxylates or blends of these two surfactant types. Fatty acid soaps are well-known flotation agents used in both mineral and non-mineral applications. These soaps are still the dominant surfactants used in the flotation deinking of ONP and OMG. However, they are relatively weak flotation collectors and are dependent on calcium to work properly in flotation deinking. The non-ionic surfactants such as fatty acid ethoxylates, nonylphenol ethoxylates, and alkoxylated polyesters are stronger collectors but have the disadvantage of higher cost, poorer selectivity and in some cases have environmental and safety issues associated with them (3). In addition, the deinking process is further complicated by the variability in the quality of the waste papers that causes additional demands on the efficacy of these surfactants. Due to the

limitations of the deinking surfactants currently available, there is a need in the industry to develop a process or reagent that is more efficient and cost effective.

In the present work, a kaolin-based deinking reagent has been developed for use in the deinking of waste paper. This deinking reagent, called DEKA 2000, is different from previous technology using kaolin clay.

Literature Review

Gaudin (4) and Schuhmann (5) described that flotation is controlled by the physical interactions between particles and bubbles. The probability of bubble-particle collision was considered to be a fundamental parameter in determining the flotation rate. Sutherland (6) proposed that the probability of particle collection, P , by a bubble could be represented by,

$$P = P_c P_a P_d$$

where P_c is the probability of collision between bubbles and particles, P_a is the probability of adhesion after collision and P_d is the probability that subsequent detachment will not occur. The assumption here is that particles have no inertia and follow the streamlines around the bubbles, which in turn are assumed to behave as non-deformable spheres. The individual probability component is defined as a function of bubble size and particle size, as well as other parameters. At a constant bubble size, flotation of a particle gets more difficult as the particle size gets too small or too big. In fact, flotation efficiency deteriorates rapidly with decreasing particle size below about 10 μm for most minerals (see Figure 1). Thus, there is a minimum particle size where flotation will not occur. In order for flotation to occur for very fine particles, the bubble needs to be smaller. However, at much smaller bubble sizes, the bubble

Thiele Kaolin Company, 520 Kaolin Road, Sandersville, Georgia, USA

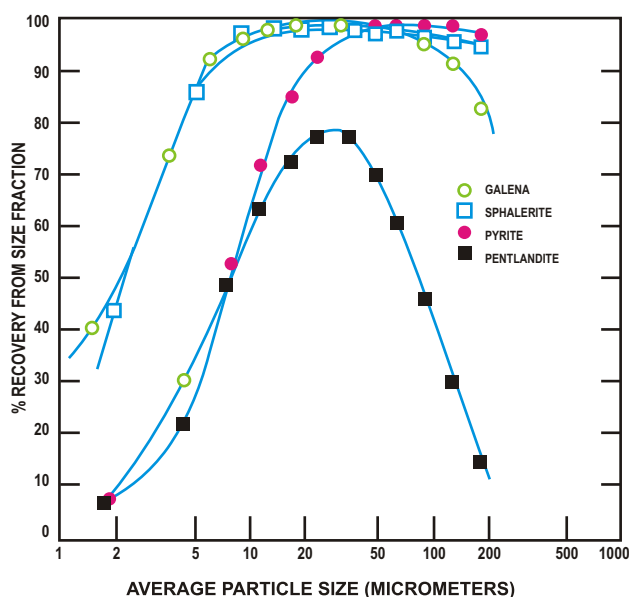


Figure 1. Effect of Particle Size on Flotation (7)

buoyancy gets affected. Therefore, at a certain minimum bubble size, the bubble will not rise to the top and float anymore. This is precisely the problem in the flotation of very fine ink particles in flotation deinking.

It is well known that ONP deinking can be improved with the use of OMG. One of the explanations for this phenomenon is that the high clay loading in the OMG coating helps improve the deinking process in ONP. However, previous work has shown that kaolin clay was incapable of consistently improving ONP deinking (8). Unlike the previous technology based on untreated hydrous kaolin clay, DEKA 2000 is based on surface modified kaolin particles. This modified clay is blended with a surfactant specifically formulated to maximize the effect of this modified kaolin in flotation deinking. The improved deinking obtained with this reagent has been attributed to the presence of the modified kaolin particles.

This mechanism can be explained through two main effects. The first effect is improved ink detachment from the pulp fibers. This is due to the hydrophobic nature of these surface modified mineral particles which results in the ink particles having a stronger affinity

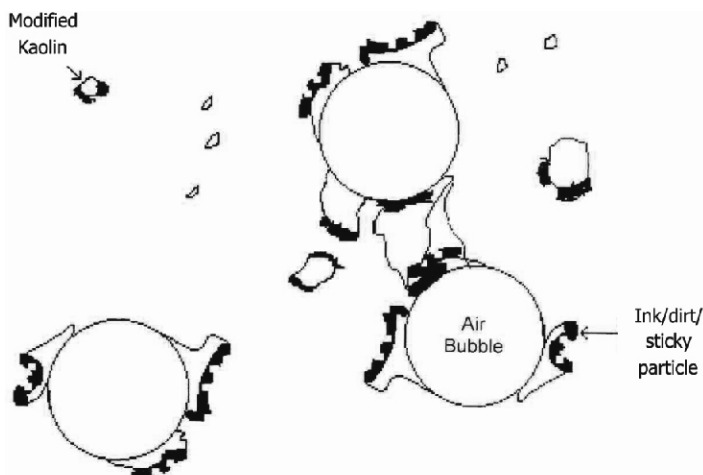


Figure 2. Schematic representation of collection of ink, dirt, and stickies particles by modified kaolin (Adapted from Fuerstenau (9)).

for them through hydrophobic interaction. The ink particles that are separated from the fiber during the pulping stage are collected by the surface modified kaolin particles of DEKA 2000. The strong hydrophobic interaction also prevents the ink particles from re-attaching to the pulp fiber, thus ensuring good separation from the fibers.

The second effect of the of the modified kaolin particles in DEKA 2000 is that due to the relatively larger particle size of the mineral particle, the probability of flotation, P_f , for the very fine ink particles is increased. This is achieved by increasing the probability of collision (P_c) between the ink particles and the air bubble. In addition, the very high hydrophobic nature of the deinking aid mineral particles increases both the probability of adhesion (P_a) and the probability that detachment (P_d) will not occur. In essence, the kaolin particles in DEKA 2000 would collect the fine ink, dirt, and sticky particles and act as flotation carriers during the flotation deinking process. These kaolin particles with the collected ink and dirt particles will then attach to the air bubbles more efficiently; thus, resulting in improved flotation separation (see Figure 2).

Results and Discussions

Tests were conducted at various paper recycling mills processing different grades of waste papers to determine the efficacy of DEKA 2000. The results presented here are average values obtained over a period one to four months of continuous testings.

Case Study 1 Recycled Office Paper Mill

A North American recycled paper mill produces office paper from 70% thermo-mechanical pulp (TMP) and 30% recycled newsprint pulp. The recycled newsprint is obtained from deinking a furnish blend containing 80% ONP and 20% OMG. The mill uses a non-ionic synthetic surfactant as a deinking reagent while the rest of the deinking chemistry is similar to standard alkaline flotation chemistry

Table 1. Case Study 1 Recycled Office Paper Mill (ONP Deinking)

Conditions	Brightness Gain*	% ERIC Reduction*	Stickies Count	% Yield
Control	+10.3	65	>10	62
DEKA 2000	+11.4	75	1	77

*Values given are after flotation only

ERIC - Effective Residual Ink Concentration

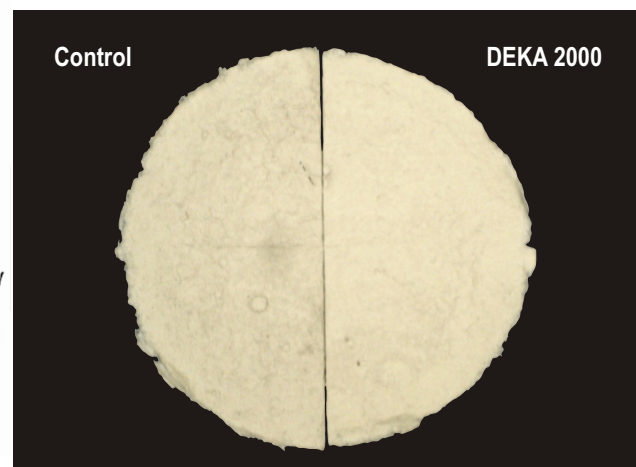


Figure 3. Deinked pads after flotation with control surfactant vs. DEKA

(i.e., Na silicate, caustic and phosphate-based chelant added). The synthetic surfactant (3 kg/ton) was replaced by DEKA2000 (2.5 kg/ton), which was added in the pulper. The goal with the use of DEKA2000 was to increase yield, reduce cost, and improve stickies removal. Results obtained with the use of DEKA 2000 are presented in Table 1 and are summarized as follows:

1. Using DEKA 2000, the brightness after flotation increased by 1 point. As shown in Figure 3, the improvement in brightness can be observed visually.
2. The ERIC dirt count reduction was improved by as much as 10 points.
3. In addition, the stickies removal was significantly improved and resulted in improved runnability in the paper machine with less picks.
4. Lastly, the flotation yield increased by as much as 15 points, resulting in significant cost reduction.

Case Study 2 Recycled Newsprint Paper Mill

In this case study, a North American recycled paper mill produces 100% newsprint from blend of OMG and ONP. Due to the poor quality of the waste paper, the mill typically uses about 70% OMG and 30% ONP in their furnish. A non-ionic synthetic surfactant is used as the deinking reagent with a near-neutral deinking chemistry (i.e., only caustic is added to the pulper to obtain a pH of about 8). In this mill, the goal is to increase the amount of ONP in their furnish so as to reduce cost. Due to the high amount of OMG in the furnish, another goal is to improve the stickies removal.

Results showing the effect of using DEKA 2000 vs. the control surfactant are shown in Table 2. As shown:

1. Brightness gain increased from +6.8 to as high as +10.
2. The amount of ONP that can be used in the feed blend increased from 30% to 45%. This resulted in a substantial cost savings.
3. The amount of dirt in the deinked pulp decreased with the use of DEKA2000.
4. The stickies removal improved significantly when the control surfactant was replaced with DEKA 2000. The paper machine ran smoother with no breaks. The caliper sensor typically had to be cleaned every 40 minutes. With DEKA, the sensor cleaning was reduced to about twice a shift.
5. Overall, the use of DEKA enabled the mill to achieve their goals.

Table 2. Case Study 2 Recycled Newsprint Paper Mill (ONP Deinking)

Conditions	Feed OMG/ONP	Brightness Gain*	% ERIC Reduction*	% Stickies Removal*
Control	65/35	+6.8	61	80
DEKA	65/35	+8.8	65	95
DEKA	70/30	+9.4	61	92
DEKA	57/43	+10.0	65	92
DEKA	55/45	+10.0	67	90

*Values given are overall from pulper to final deinked pulp

Case Study 3 Recycled Paper Board Mill (White Top Liner)

Recycled Paper Mill 3 located in North America produces recycled

paper board with a top liner made from waste paper, mainly unprinted sorted white ledger (SWL), mill broke, and other pre-consumer unprinted waste. The mill uses a near-neutral deinking chemistry with a small amount of non-ionic surfactant (0.5 kg/ton) when needed for foaming. The desired objective of this mill is to be able to use poorer furnish, specifically by adding post-consumer/printed waste paper such as SWL, MOW, and coated white paper. The results of using DEKA 2000 are presented in Table 3 and the results are summarized as follows:

1. Using DEKA2000, the brightness increased by >5 points.
2. Significantly lower dirt count was obtained with the use of DEKA 2000.
3. With DEKA 2000, significant reduction in overall cost was achieved due to increase in the amount of printed waste paper in the furnish.

Table 3. Case Study 3 Recycled Paper Board Mill (White Top Liner)

Conditions	Brightness Gain*	% ERIC Reduction*
Control – 10% postconsumer waste	+4.6	56
DEKA – 40% post consumer waste	+8.2	65
DEKA – 80% post consumer waste	+10.3	70

*Values given are overall from pulper to final deinked pulp

Case Study 4 Recycled Office Paper Mill

Case Study 4 involved a recycled paper mill located in North America that produces recycled office paper, envelopes and uncoated offset paper. The mill recycles poly-coated white board such as waste coffee cups, ice cream containers, frozen food boxes, magazines, coated book, undelivered mail, and catalogs in producing their various products. The poly coating is separated from the fiber using high consistency pulping, followed by a series of perforated and slotted screens with progressively smaller hole and slot openings. An enzyme-based deinking reagent is added at the pulper at a dosage rate of 3.75 kg/ton with a standard alkaline chemistry. The objective for this mill is to reduce cost by replacing the more expensive enzyme-based deinking reagent and using a poorer furnish.

Table 4 shows the deinking mill performance obtained with the control deinking reagent and DEKA 2000. The results indicate the following:

1. Replacing the enzyme-based reagent with DEKA 2000 allowed the use of 15% flexo-printed paper in the feed furnish.
2. Using DEKA 2000 results in an increase in brightness of 2 points.
3. The dirt count is lower with DEKA 2000 and the color is improved.
4. The objective of reducing cost was obtained with the use of DEKA2000.

Table 4. Case Study 4 Recycled Office Paper Mill (Poly-coated Board and SWL deinking)

Conditions	%Flexo-printed Paper	Dirt Count	L	a	b	Final Brightness
Control	0	1.4	93.15	1.31	-3.90	85.9
DEKA	15	0.9	93.88	1.36	-4.29	87.9

*Values given are from final deinked pulp

Conclusion

A kaolin clay-based deinking reagent, DEKA 2000, was developed for flotation deinking. This deinking reagent is produced by the surface modification treatment of kaolin clay to make the mineral surface hydrophobic and then blended with a surfactant specially formulated for this kaolin-based material. This novel deinking reagent is capable of improving the deinking of various waste papers such as ONP, OMG, MOW, and blends thereof.

Case studies conducted at various recycled paper mill showed the following advantages with the use of this deinking reagent:

- increased DIP brightness
- lower ERIC values
- improved stickies removal
- higher yield
- and enabled the use of poorer furnish.

Experimental

Brightness measurement was conducted by forming the deinked pulp (DIP) into a pad, oven dried, and the GE brightness measured using TAPPI Test Method T-218 with a Technidyne Brightimeter Model Micro S-5. In addition, the Effective Residual Ink Concentration (ERIC) was measured by using a Technidyne Technibrite ERIC 950.

For the measurements of macro-stickies, the main method used is that described by TAPPI Test Method T-277. In this method, the pulp is screened with a Pulmac Masterscreen (0.006-inch slots) and the rejects are collected on a black filter paper. This was then pressed against a white coated paper, which in turn picks up the stickies and then measured using image analysis.

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