RECYCLING AN ENVIRONMENTALLY BENIGN PSA USING A WOOD-FREE RECOVERED PAPER FURNISH

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CLOSED LOOP PILOT PLANT STUDIES CONSIDER THE IMPACT OF POSTAGE STAMP PSAS ON THE RECYCLING INDUSTRY.

THE U.S. POSTAL SERVICE, IN COOPERATION WITH Forest Products Laboratory (FPL), has actively sponsored a research campaign to quantify the impact of PSA (Pressure Sensitive Adhesive) postage stamp adhesives on the recycling industry and, ultimately, the consumer. A portion of this research centered upon two recent process system trials at the Voith Paper Technology Center in Appleton, WI.

The model system used for the two trials consisted of high density cleaning, coarse screening with //0.30mm C-Bar slots, fine screening with //0.10mm C-Bar slots, primary and secondary ECO flotation, 60mm forward cleaning, Ø 75mm through flow cleaning, washing, twin wire belt press thickening, and DAF water loop clarification. The quantification of stickies was carried out in accordance with TAPPI Test Method T 277 pm-99 and FPL protocol.

The first trial, using a mixture of three types of PSA, showed that more than 99% of stickies are removed in our representative recycle process, with the vast majority (>98%) being removed via slotted screening. The second trial was performed using a single highly tacky PSA. This trial was performed to determine the effect of this PSA material on mill equipment runnability and maintenance.

The results show no measurable final product impact beyond what is typically found using present grades of recycle furnish. The same high stickies removal efficiencies were again found in this second system run. No noticeable affinity for deposition on internal piping and equipment was discerned. This PSA material exhibited a higher level of shear and tensile strength as well as a propensity to adhere to itself and create balled stickies over 25mm in diameter. These balled stickies were only noted in the coarse screen (//0.30mm C-Bar) reject stream.

BACKGROUND

A blind study was conducted concurrently at several research facilities (including the Voith Sulzer Technology Center) to determine laboratory screening potential for 14 different combinations of unprinted PSA/backing/release liner stamp candidates. The PSA stamp materials were evaluated for ease of PSA removal and graded accordingly. This work was quite successful in demonstrating that these PSAs could be removed during slotted laboratory flat screening; however, the next step in the recycle process had to be proven. This entailed scaling up this lab work to a full scale pilot plant system trial with slotted C-Bar pressure screening. More than 99% of the PSA contaminants were removed.

This work was reported during the U.S. Postal Service PSA Conference in July 1997. Later work repeated this trial with the addition of flotation deinking, using a mixture of three different printed PSA/backing/release liner sandwiches, copy paper, and envelope paper. PSA level by weight was approximately 0.9%. Again, this work was demonstrated successfully. The final step in this testing process was conducted next, and it is the subject of this report.

// Denotes slotted screening
ø Denotes hole size and/or diameter

OBJECTIVE

The objective of this trial study was to determine and, if successful, validate the benign nature of the PSAs in a representative recycle system. Earlier work has demonstrated that high concentrations of PSA material can be removed at a high efficiency level. This test was conducted at a PSA contamination level proportional to an expected recycle furnish mixture. A successful test would show:

1. A reduction of the system accept PSA to a level at or below a typical recycled pulp plant accept quality limit
2. Proof that this highly tacky PSA does not adversely impact runnability and/or maintenance.

This trial was conducted over a two-day period. The first day involved operating the system and gathering samples. The second day consisted of opening each machine module and noting interior stickies depositions, buildups, or concentrations of the PSA contaminant.

PROCEDURE

A typical recycle facility model was used, as in the earlier open water loop work, but with several changes:

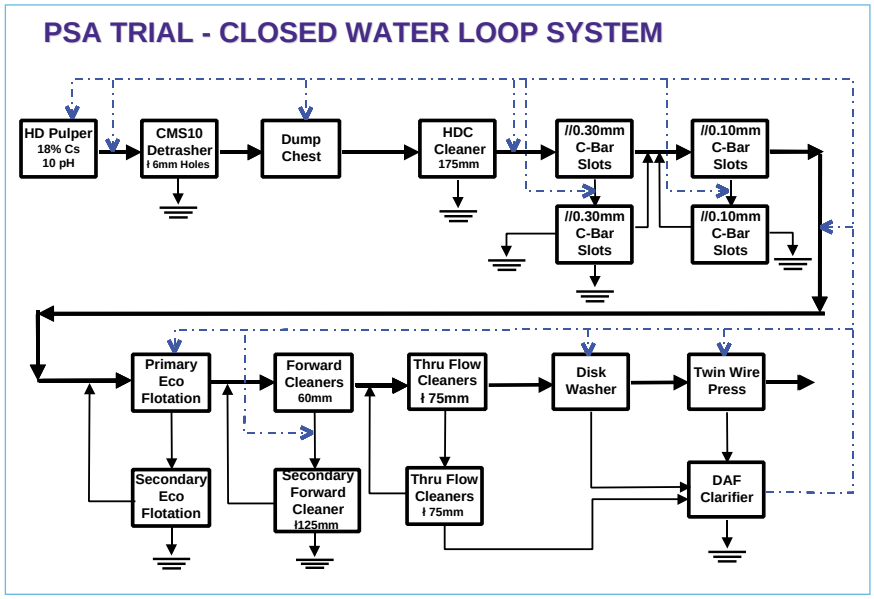
1. The stickies portion of the furnish consisted of a highly tacky PSA sandwiched between printed stamp stock and envelope stock, illustrated in **Fig. 1.**
2. Flotation deinking was added to remove the printing from the stamp material and contribute toward floating out residual stickies content.
3. Coarse slot screening was added in place of coarse hole screening.
4. The system water loop was closed by clarifying the through flow cleaners, washer, and belt thickener effluent streams.

The entire tested system was set up in this order, as illustrated in the diagram in **Fig. 2**: high consistency (HD) pulping, coarse detrashing through Ø 6mm extraction holes, high consistency (HDC) cleaning, two-stage coarse screening with //0.30mm C-Bar slots, two-stage fine screening with //0.10mm C-Bar slots, primary and secondary ECO flotation, two-stage Ø 60mm forward cleaning, two-stage Ø 75mm LT3 through flow cleaning, washing, twin wire belt press thickening, and DAF water loop clarification. The washer, LT3 cleaner, and belt thickener effluent was clarified and returned to the process.

1. Printed stamp stock/PSA/envelope paper

The furnish consisted of equal portions of pre-consumer envelope and copy paper with the PSA sandwich comprising 1.8% by weight of the total. The PSA portion of the sandwich was 10%, by weight, or 0.18% of the total tested furnish. Approximately five tons of this recipe were pulped at 18% consistency, 115°F, 10 pH, with a 20 min batch time. High Point DI 700A surfactant, 0.1% by weight, was added at the pulper. The clarifier used a two-part coagulant/flocculant polymer chemistry. The coagulant dosage added was 14 ppm of Buckman Bufloc 5031 and 5 ppm of Bufloc® 565.

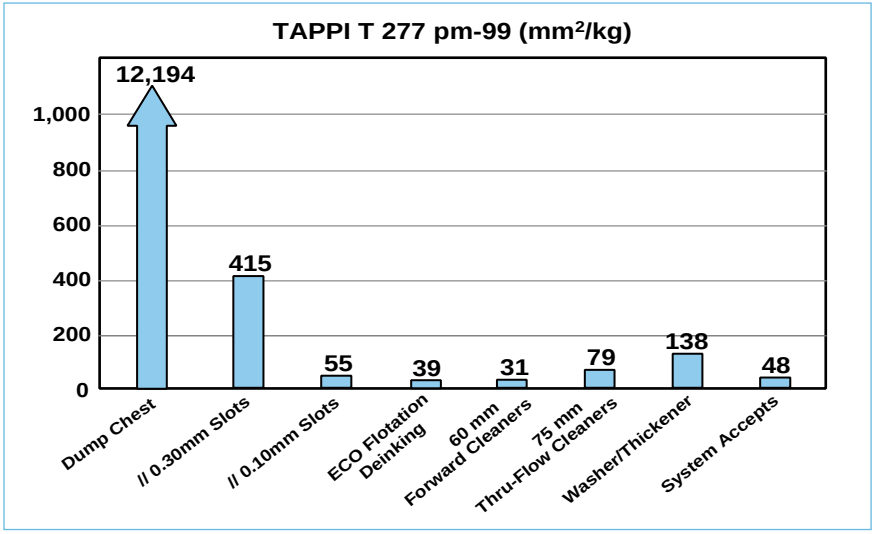
The internal surfaces of the system components were cleaned and visually inspected before the start of the trial. After the trial, the system component surfaces were again inspected to ascertain whether the PSA material deposited and adhered to any internal equipment sur-



2. Closed water loop system

System Module	TAPPI T 277 pm-99 Stickies [mm²/kg] Feed	Accepts	FPL Blue Dye Stickies [ppm] Feed	Accepts	Visible Dirt >ø 80 µm [ppm] Feed	Accepts	Ash @525°C [%] Feed	Accepts
//0.30mm C-Bar Screen	12,194	415	77.8	36.2	60.8	58.3	10.31	-
//0.10mm C-Bar Screen	689	55	29.4	29.7	60.1	67.4	-	-
Eco Flotation	130	39	37.1	14.6	65.4	17.8	10.56	2.89
KS60 Forward Cleaners - ø60mm	39	31	14.6	10.5	17.8	12.4	-	-
ø75mm LT3 Thru-Flow Cleaners	31	79	10.5	16.3	12.4	18.7	-	-
Hydrodisk™ Washer	79	138	16.3	12.8	18.7	17.9	2.76	2.45
HC 750 Belt Press	138	48	12.8	11.0	17.9	12.9	2.45	1.24

I. Closed water loop system data summary, June 15-16, 1999



3. Stickies concentration

faces. Sample acquisition consisted of obtaining a three-part composite sample from the feed and accepts portion of each system's primary stage module during the course of stable operation. Stable operation is defined as all flows and chest levels maintained in equilibrium for a minimum of 1-2 h. The quantification of stickies was carried out in accordance with TAPPI Test Method T 277 pm-99 and FPL protocol.

Figure 3 is a histogram of test results showing the level of measured contaminants; it was constructed to visually track the residual PSA contamination concentration as the stock passed through our test system.

RESULTS

After system hydraulic equilibrium was achieved, a three-part composite sample was taken at the feed and accept points of each machine module within the pilot plant system. Testing was performed on each discrete resultant pulp mixture. Screening, flotation, forward, and through-flow cleaning modules were operated between 0.8-1.2% consistency. System yield (77.5%) was calculated by physically measuring and timing each reject stream. The summarized test results are listed in **Table I.**

These results show that the system PSA removal efficiency was well over 99% using the TAPPI Test Method T 277 pm-99 test method. Typical industry system removal rates, using this test method, range from 90-99% for this type of stickie with thin stock //0.10mm slotted screening and C-Bar Technology.

Looking at the individual machine modules reveals that the great majority of stickies (PSAs) removed were rejected from the //0.30mm slotted screening portion of the system run. These PSA stickies also exhibited a great affinity for self-adherence. This is shown by the discovery of balled stickies, shown in **Fig. 4**, that were found in the secondary //0.30mm coarse slotted screen rejects. Note that the balled stickies were not found in the primary stage of coarse slotted screening nor in either stage of the //0.10mm secondary screens, shown in **Fig. 5**. We theorize that since the secondary stage coarse slotted screen was operated in intermittent reject mode, the stickies had time to join and ball up before discharge. The primary stage coarse screen was operated with continuous rejects to the secondary stage. This provided us with an opportunity to compare the two screens. No balled stickies were found in the first stage with continuous rejects; therefore the balling of the stickies occurred in the secondary stage coarse screen rejects.

After the first module of slotted screening (//0.30mm C-Bar), per TAPPI Test Method T 277 pm-99, more than 96% of the PSA stickie contaminants had been removed. Visible dirt counts (>80µm) show over 78% removal efficiency. After the pulp passed through the second stage of fine cleaning, 99.5% of the original stickies had been removed. Overall system removal efficiency was 99.6%,

4. Example of "balled" PSA material

5. No evidence of PSA buildup on screen interior

indicating that no significant stickies were left in the system after these first two screening modules. Dirt counts did not show any meaningful removal efficiencies, as we used pre-consumer copy and envelope paper. The FPL Blue Dye stickies test seems to correlate better with dirt count information (~95% correlation) than with the TAPPI Test Method T 277 pm-99 (~73% correlation). However, the general removal trends do agree.

After fine slotted screening, the stickies level (55mm^2/kg) was reduced to a point at or below the need for further treatment. The sample data bear this out, as the final stickies level after flotation, cleaning, and washing is 48 mm^2/kg.

The second day of the trial consisted of washing out the system and inspecting for any adherence of the PSA sticky material to any interior surfaces. In order, we inspected the HD pulper, //0.30mm C-Bar pressure screens, //0.10mm C-Bar pressure screens, the interior of the ECO flotation cells, the washer disk mesh, and the HC press wire. No PSA deposition evidence was found at any of these locations. As explained before, we did find evidence of balled stickies in the reject stream of the secondary //0.30mm slotted screen, as shown in **Fig. 6**. Some of these balled stickies also were found in the feed side of the interior of this same basket. The size and shape were consistent with the reject stream stickies, and none were found adhered to the inside or on the accept side of the screen.

The CMS 10 detrasher extraction plate, shown in **Fig. 7**, also was closely inspected for the appearance of the balled stickies. In order to prove the origin of the balled stickies, we tracked the size and shape of the stickies present in the pulp prior to screening.

The PSAs appeared completely broken into Ø 3-5mm pea size or smaller pieces during HD pulping. The detrasher rejects revealed a few of these stickies recombined into larger balled shapes (some as large as Ø 8-10mm). The detrasher was equipped with Ø 6mm holes in the accepts screen plate. Primary //0.30mm pressure screen rejects showed no particles larger than Ø 3mm. However, visual inspection of the secondary rejects of the coarse slotted screen show some of these stickies rejects must have combined as "balls" as large as 40-50mm in diameter. It is apparent that this was due to the intermittent operation mode of this screen. Between purge cycles, the rejects are circulated inside the center of the screen and concentrated. Due in part to the high tackiness, the rotor acts to help roll the individual PSAs together. Before they become too large and act to plug the screen, they are purged (every 5-6 min). In the fine slotted loop, the secondary screens were run in continuous reject mode, and this "balling" effect did not occur.

STICKIES TEST METHOD

The amount of adhesive stickies in the process was evaluated by both FPL protocol and TAPPI Test Method T 277 pm-99.

In the FPL protocol, 15 1.2 gm handsheets at each sample point were dyed with a blue dye solution, which was made by dissolving Keystone Solvent Blue 58 in a mixture of toluene and isopropynol. The dyed handsheets were then washed with methanol to remove dyestuff retained in fibers. Adhesive particles remained light to dark blue after washing. These particles were then detected and quantified with an image analyzer. The amount of stickies is expressed as ppm.

In TAPPI Test Method T 277 pm-99, 100 grams o.d. for each sample point was required to fulfill statistical confidence requirements. Each sample was first screened with a 0.10mm slotted laboratory flat screening device. The retained debris was then transferred to a black filter paper. Against a white stickie pick-up coated paper, the debris and black filter paper were heated and pressed at 190°F and 13 psi. Under this heat and pressure, stickie particles pick the white coating and set onto the filter paper. This filter paper was then washed with spray water, removing all non-tacky materials. Stickie particles were revealed as white particles against a black background. The stickies were then measured and quantified with an image analyzer. The amount of stickies is expressed here as mm^2/kg.

6. Secondary slotted screen showing some PSA. Note that most are fiber flock with no PSA content.

7. Detrasher interior: no PSA, no "balled" PSA evident

CONCLUSIONS

No stickies were visibly apparent in the pulp after fine slotted screening. Testing quantified and confirmed this, showing more than 99% removal efficiency using TAPPI Test Method T 277 pm-99. PSA postage stamp stickies can be effectively removed during recycling.

No PSA runnability issues were noted that would affect final pulp quality.

The PSA used for this trial has a tendency to ball up and agglomerate when concentrated in a secondary screen with intermittent timed rejects. The "balled" stickies are neither a maintenance nor a runnability issue, provided that the rejects screen is run in a continuous fashion or a reduced time between purge cycles. TJ

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