ENVIRONMENTALLY BENIGN USPS STAMPS: BASELINE PILOT RECYCLING RESULTS

D. F. Seiter - Sr. Research Scientist
M. A. Pikulin - Group Leader
R. G. Meese - Sr. Research Scientist
Union Camp Corporation
P. O. Box 3301
Princeton, NJ 08543

Said Abubakr - Research Project Leader
David Bormett - Chemical Engineer
Nancy Ross-Sutherland - General Engineer
Forest Products Laboratory
One Gifford Pinchot Drive
Madison, WI 53705

Abstract

Stickies continue to represent the most challenging contaminant to remove from recycled secondary fiber. Current projections suggest that pressure sensitive adhesive (PSA) markets will continue to grow rapidly, increasing the concentration of these contaminants in common office-pack wastepaper. PSA's reformulated to exhibit higher removal efficiencies within standard secondary fiber processing equipment are expected to prove effective in alleviating cleanliness demands for the recycling industry. The US Postal Service, in their program to develop postage stamp adhesives that do not adversely affect the environment, have focused considerable efforts on developing a benign PSA stamp product for recycled fine paper operations. This program has encompassed both laboratory and pilot plant recycling studies to quantify the removability of such adhesives and high removal efficiencies have recently been reported. In order to translate pilot removal efficiencies to commercial full scale recycling operations, a baseline wastepaper recycling study using conventional stickie and dirt contaminants was run at the Forest Products Laboratory pilot facility. Contaminant removal efficiencies of 50% across fine slotted pressure screens were observed for these conventional contaminants, and were significantly lower than the reported removal efficiencies for reformulated stamp adhesive materials: Likewise, final product dirt levels were 2-3 times greater for the conventional contaminants, when compared to the reformulated adhesive, despite comparable initial contaminant levels. The relatively low yields observed in the pilot facilities may have impacted overall removal efficiencies and are being addressed through protocol modifications.

I. Introduction

Union Camp has been operating a recycled fiber plant of their own design at the Franklin, Virginia tine paper operation since December, 1994. The plant produces 300 tons per day of recycled fiber which is integrated into the mill pulp supply system. The Franklin mill is one of the largest fine paper operations in the world, producing more than 2,000 tons per day of bleached paper and paperboard products, including a variety of grades with recycled fiber content.

The recycled fiber operation uses a mixture of sorted office waste and sorted white ledger to produce a recycled pulp with typical brightness of 85 to 87 ISO and dirt in the 5 to 7 ppm range (TAPPI 0.04 mm^2). This level of quality requires a complex process design using a number of unit operations specifically aimed at removing contaminants. Included in these operations are pulping, screening, forward and reverse cleaning, kneading, flotation and various washing stages.

The combined unit operations at the Union Camp deinking facility are highly effective in removing stickies, and stickies remaining in the final product are sufficiently low in number to avoid the problems typically associated with paper machine operations. Stickies do, however, manifest themselves as dirt in the final product. Stickie materials surviving the process tend to pick up ink and other contaminants and can cause product appearance problems.

A key product quality factor has been the rapid shift in marketplace expectations. When recycled fiber products were introduced a number of years ago for printing and writing grade applications, a mottled or "dirty" sheet appearance was not only acceptable, but was frequently emphasized to distinguish the recycled fiber content of the product. This was, however, a short-lived trend and the marketplace quickly demanded higher quality standards for fine paper recycle content grades.

Recycled content fine paper products must now be comparable to virgin fiber product quality, at a comparable cost, to gain wide acceptance in the marketplace [1].

Consistent with industry reports, past sampling studies within Union Camp's Fiber Recycling Plant suggest that pressure sensitive adhesives (PSAs) comprise a major component of adhesives that cause stickies. Aware of such concerns, the U. S. Postal Service (USPS) is committed to developing PSA stamp products that can be successfully recycled into paper products in a typical recycling facility, particularly those plants supplying pulp for printing and writing grades[2]. Successful development of recyclable adhesives by the USPS can provide the momentum needed to move these products into the broader adhesives market and will be a major step forward to resolve the issue of stickies in recycled paper products.

The USPS is the largest single consumer of pressure sensitive adhesives within the U. S. Currently, approximately 12% of domestic PSA production is purchased by the USPS[3]. PSAs are employed in over a dozen USPS applications, and are commonly used by the USPS to manufacture the *no-lick* stamp. Within the last 5 years, such stamps have realized high growth rates, moving from 5% of all stamps (1993) to 82% in 1997.

Current USPS criteria for PSA formulations require acceptance through three separate testing arenas:

1. Laminate specification certification.
2. Springborn Testing Laboratories - bench scale recycling studies.
3. Forest Products Laboratories - pilot recycling studies.

Pilot plant work at the Forest Products Laboratory using reformulated adhesives for stamps is highly encouraging. Several PSA reformulations demonstrate 95+% removal efficiencies. The USPS believes, however, that the final testing necessary prior to claiming success is confirmation through commercial deinking facility trials. Prior to committing to such a trial, Union Camp required an assessment of the FPL pilot recycling protocol through a baseline recycling study. This pilot trial provided a suitable reference to the high stickies removal efficiencies noted in prior stamp PSA runs.

II. Comparison of Recent FPL PSA Recycling Runs to Commercial FRP Stickies/Dirt/Yield

The FPL pilot facility incorporates most unit operations commonly employed by modern deinking facilities. These include a high consistency batch pulper, pressure screens, flow through cleaners, forward cleaners, flotation, washing and pressing (see reference [4]). They also have a dispersion unit and a pilot paper machine that are not routinely employed in the protocol. Noticeably absent are kneaders and bleaching stages. As none of the USPS PSA stamp runs included printed material and dyed/colored paper stock, neither of the latter two unit operations were necessary.

Pilot runs and analytical techniques have been conducted in an identical manner for all runs [4]. Stock processed through the pilot plant and reported by the USPS included 5 benchmark paper and stamp combinations and 7 paper and stamp combinations using reformulated PSAs. Release liners were included in selected pilot runs to determine recyclability of that material as well.

Benchmark Stock

1. 100% copy paper
2. 100% stamp stock facing paper
3. Linerless PSA stamp stock, adhered to paper
4. Standard PSA stamp stock, retained on release liner
5. Standard PSA stamp stock, adhered to paper

Reformulated PSA Stock (7 total)

1. Reformulated PSA stamp stock, retained on release liner
2. Reformulated PSA stamp stock, adhered to paper

Similar to Union Camp's stickies analysis techniques, the FPL uses a standard flatbed scanner and image analysis software to quantify stickies. However, as no other contaminants are introduced within the recycling runs, FPL stickies can be

measured directly from dirt handsheets and reported as dirt in ppm (>0.02 mm^2 physical dirt). To improve stickies resolution, samples are dyed and back-extracted prior to scanning [5]. The stickies databases for the 19 runs are documented in their entirety in reference [6]. Key findings from these runs are summarized in Table 1.

	Initial	Final Product	Removal Efficiency (%)
FPL Copy Paper, ppm	1.2	9.8	---
FPL Linerless PSA Stamp, ppm	900 - 1700	2 - 10	99 + %
FPL Standard PSA Stamp, ppm	2100	19	99%
FPL Reformulated Adhesives, ppm	380 - 2700	2 - 162	81 - 99+%
UCC product dirt, ppm [1]	800 - 2000	5 - 7	98 + %

Table 1 - USPS-FPL Pilot PSA Recycling Protocol: Stickies Concentration

Although the Union Camp Fiber Recycling Plant commonly operates at 98+% dirt removal efficiencies, stickies removal efficiencies are generally lower. Reformulated adhesives submitted to the FPL proved to be highly removable, and well above the typical UCC plant stickies removal efficiencies. This suggests that the adhesive manufactures have realized significant success in formulating more recyclable adhesives. It should also be noted that these adhesives have all passed the rigorous mechanical testing required of all USPS stamp adhesives.

One concern regarding the accuracy of the recycling protocol was the low fiber yields reported by the FPL. As shown in Table 2, FPL yields are well below industry expectations of 60% to 80%. As the FPL protocol does not include fiber recovery steps, such yields are certainly plausible. However, with no fiber recovery unit operations, contaminant removal efficiencies reported by the FPL will be higher than those anticipated in a commercial facility.

	Fiber Yield, %
Industry standard yields	60-80%
FPL - Copy Paper	34%
FPL - Linerless PSA Stamp	36-38%
FPL - Standard PSA Stamp	44%
FPL - Reformulated Adhesives	38-45%

Table 2 - USPS - FPL Pilot PSA Recycling Protocol: Fiber Yields

A proprietary UCC steady-state process model was used to estimate FPL stickies removal efficiencies at higher yields. This steady-state model projected an approximate 12% reduction in FPL stickies removal efficiency (99% removal at 44% yield is estimated to drop to 87% removal at 72% yield), still a significant improvement in recyclability.

III. FPL Trial - Approach

The FPL baseline trial served primarily to project how the above reported PSA recyclability studies would translate to commercial performance. A representative SOW feedstock was composited at Union Camp's Fiber Recycling Plant Warehouse. As the protocol contains no bleaching stages, efforts focused on minimizing colored and dyed material from the waste supply. The wastepaper was composited as described below:

Wastepaper - The FPL high consistency batch pulper has a capacity of 114 kgs, about one tenth the size of an average wastepaper bale. 4 SOW bales were identified for sampling at the UCC recycling plant. Samples from the

bales were acquired by feeding the bales through the sorting conveyor and sampling at specified intervals. A minimum of 15 samples per bale was acquired. A total of 130 kgs of wastepaper from all bales was composited. Colored material and prohibitives were removed and quantified.

FPL Recycling Run - The complete procedure for the pilot facility is supplied in reference [4]. This same procedure was followed for the baseline run as well. Specific unit operation parameters are summarized below:

Pulper: 114 OD kgs. 115°F, 20 minutes, 10 pH, 14% consistency.

Pressure Screens: Voith vertical pressure screens, 0.012" to 0.006" in series, 1.1% consistency, 15% reject rate.

Forward Cleaners: 25 psi dP, 0.65% consistency, 15% reject rate.

Reverse Cleaners: 20 psi dP, 0.65% consistency.

Flotation: 4 lpm airflow.

Washing: 70 mesh washing over sidehill screen.

Pressing & shredding: Hydraulic press to 30-35% consistency.

Dispersion: Bauer pressurized refiner, 12" *devil's tooth* plates.

IV. Analytical Methods

The FPL pilot facility performance was gauged through dirt measurements and stickies measurements. Dirt handsheets were constructed and scanned at the FPL to permit direct comparisons between this baseline SOW trial and the previously reported PSA runs. Dirt handsheets are constructed at the FPL from 1.2 grams of disintegrated stock sample [5]. Prior to this baseline run, all detectable dirt contaminants were assumed stickies by the FPL. This was a fair assumption as all the PSAs were recycled using a clean unprinted carrier stock. Dirt is quantified by imaging 10 handsheets using a 600 dpi flatbed scanner and standard imaging techniques. Only contaminants of areas greater than 0.02 mm^2 are reported. To better resolve contaminants, the FPL also dyes each handsheet with a mixture of Morplass Blue followed by heptane extraction. The dyed handsheets were scanned using the Optimax Spec Check software at a standard threshold of 100 gsv (on a 0-254 total scale).

Dirt handsheets were also constructed and scanned by Union Camp to permit direct comparisons of the FPL baseline study to the UCC plant performance. Dirt handsheets are constructed using 3.0 grams of disintegrated stock. Two handsheets are constructed and scanned on a camera-based system, providing both physical and effective black area (eba) measurements. Scans are performed on the dirt sheets until either a maximum field or minimum uncertainty is attained. Reports are generated for subvisible dirt, > 0.02 mm^2 dirt and > 0.04 mm^2 dirt. Current UCC plant final product quality is typically 5-7 ppm e.b.a. (> 0.04 mm^2).

Union Camp also employs a stickies analytical method as well. Stickies are quantified either by physical count (quality control) or standard imaging techniques (process 'optimization). All stickies reported in this study represent scanned stickies. Stickies are separated from the stock by diluting 100 OD grams of the repulped stock to a 1% consistency and screening through a Pulmac MasterScreen™ fit with a 0.15 mm (0.006") slotted screen. Screened rejects are collected on a filter paper and transferred to acetate sheets for image analysis. Non-stickie contaminants are physically removed using a probe and stereomicroscope. The acetate sheets are then scanned using a flatbed scanner (600 dpi HP Scanjet 4C) and standard image analysis software (Apogee SpecScan). Stickies are reported in units of scanned count per 100 OD grams and scanned average stickies size (mm^2).

V. FPL Trial - Results

Four bales identified as representative SOW bales were composite sampled at the UCC plant. Random samples were taken at equivalent time intervals, as the wastepaper passed through the conveyor. The samples were sorted as they were collected, according to the following criteria: coated, color dyed, out-throws, prohibitives and stickie material. It should be noted that aside from a slight bias towards stickie material, the samples were random. That bias towards stickie material was performed to ensure significant quantities of stickies within the feed-stream. It is well known that the majority of stickies comes from a small minority of wastepaper contaminants: had such a source been missed, meeting the trial objective would have been jeopardized. The results of the composite wastepaper sort are illustrated in Figure 1.

Certainly with respect to ash, colored papers and out-throws, the sample composited from the wastepaper bales was representative of common wastepaper. The stickie material, however, was somewhat higher than current specifications. As noted above, we chose to err on the high side of stickies material to ensure such contaminants would be detectable in the FPL run.

A. Stickies Removal Efficiency

Stock samples from the thirteen different unit operations were collected and shipped to Union Camp for stickies analysis. Figure 2 illustrates the stickies count profile throughout the process as measured by Union Camp. Also included in Figure 2 are typical UCC stickies values. Clearly, the high stickies material from the feed wastepaper sort translated to much higher stickies counts than are typically encountered at the UCC plant pulper. However, average stickies size profiled in Figure 3 indicate that repulped stickies sizes are comparable between the pilot and commercial repulpers, and excessive stickies breakup in the FPL repulper was not a concern. Higher stickies counts in the FPL repulper were thus attributed to higher adhesive contaminants in the feed.

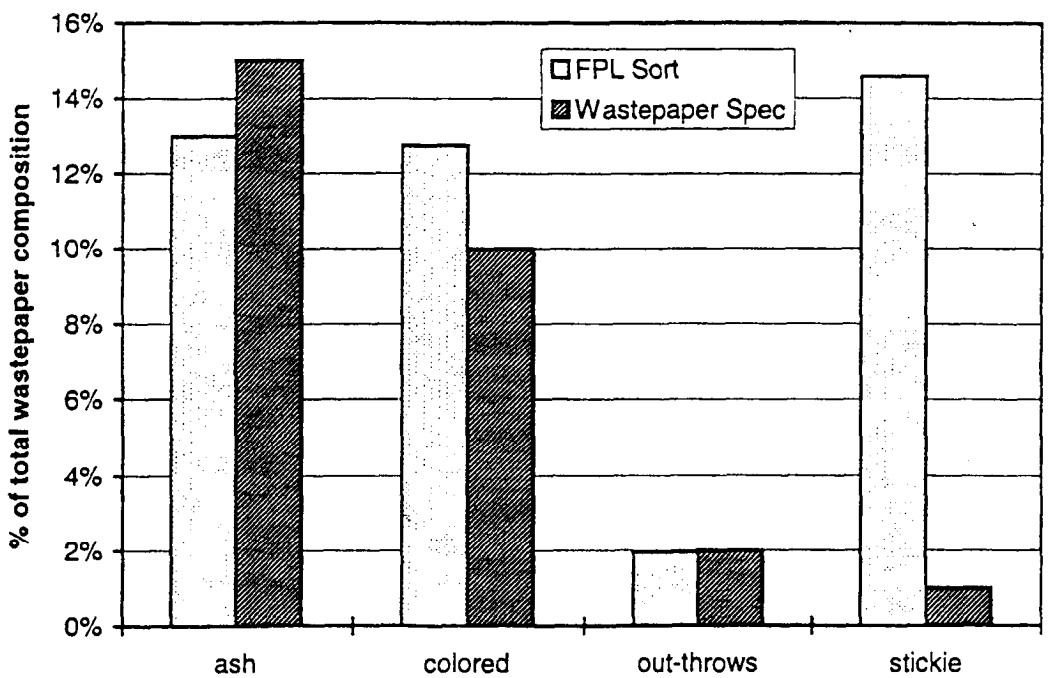

Figure 1 - FPL Baseline Pilot Recycling Run: SOW Supplied to FPL

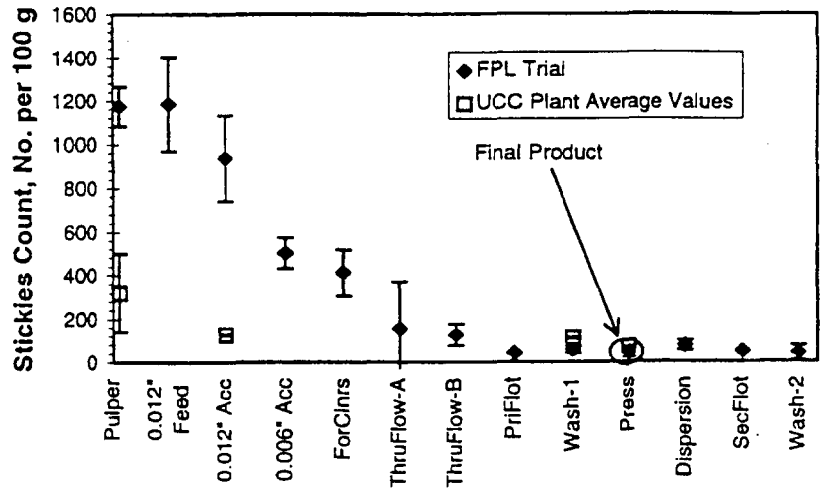

Figure 2 - FPL Pilot Baseline Run: Stickies Count Profile

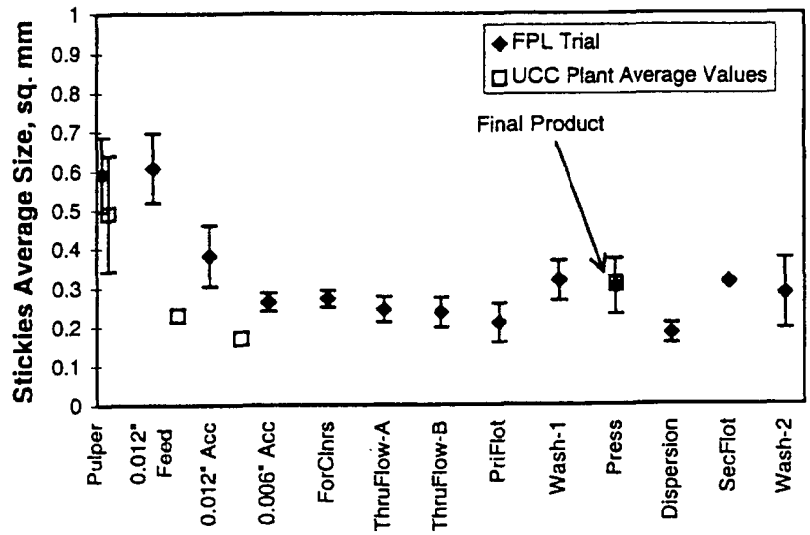

Figure 3 - FPL Pilot Baseline Run: Stickies Size Profile

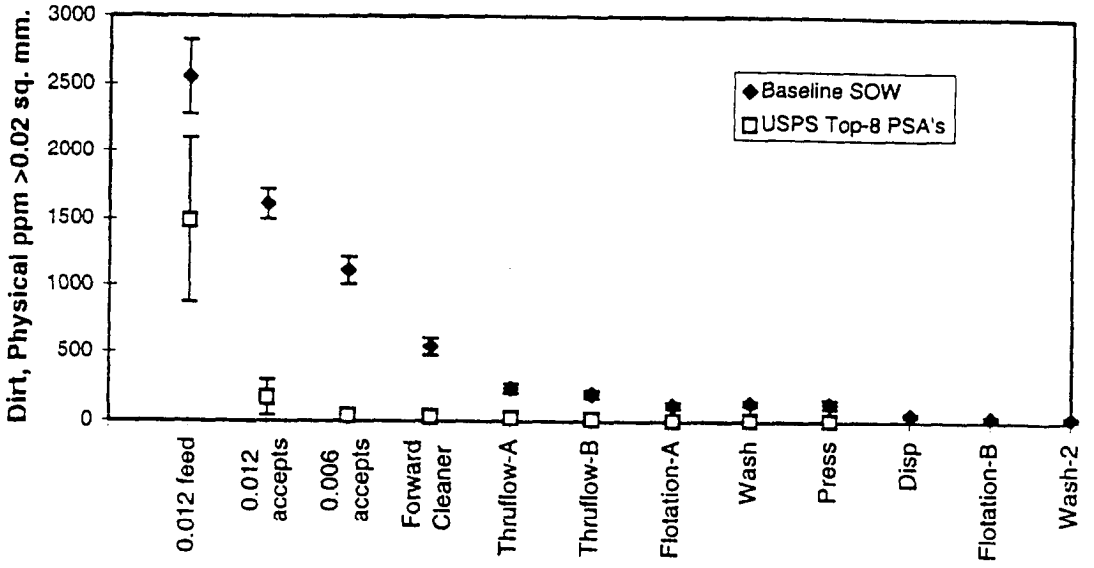

Figure 6 - FPL Pilot Baseline Run: Dirt Profile as Measured at FPL

	Pulper	Final Product	Removal Efficiency (%)
Copy Paper	1.2	9.8	---
Top 8 USPS PSAs	1488 • 613	7 • 4	99.5
Baseline SOW	2550 • 276	130 • 45	98.9
Baseline SOW with add'1 disp., 2° flotation and 2° wash	2550 • 276	36 • 13	98.6

Table 3 - FPL Pilot Recycling Trial: FPL Dirt Measurements: FPL Techniques (all value ppm physical dirt > 0.02 sq. mm as determined at FPL)

UCC-plant Dirt Measurements: Figure 7 illustrates the dirt profile across the FPL pilot system for both the baseline SOW stock as well as UCC average dirt values. Immediately apparent is the significantly higher dirt content in the UCC plant feed stock, when compared to the FPL feed. This feed dirt content discrepancy may be attributed to several factors, including: variation in specific feed stock, differences in process water management or differences in applied pulper energy. Regardless of the cause for higher plant feed dirt, dirt content through the forwards cleaners prove nearly equivalent in both processes. By the final press mat, UCC plant final dirt content actually proves significantly lower than the FPL final dirt. The higher UCC dirt removal efficiency is largely attributed to the use of kneaders that detach the toner From the fiber.

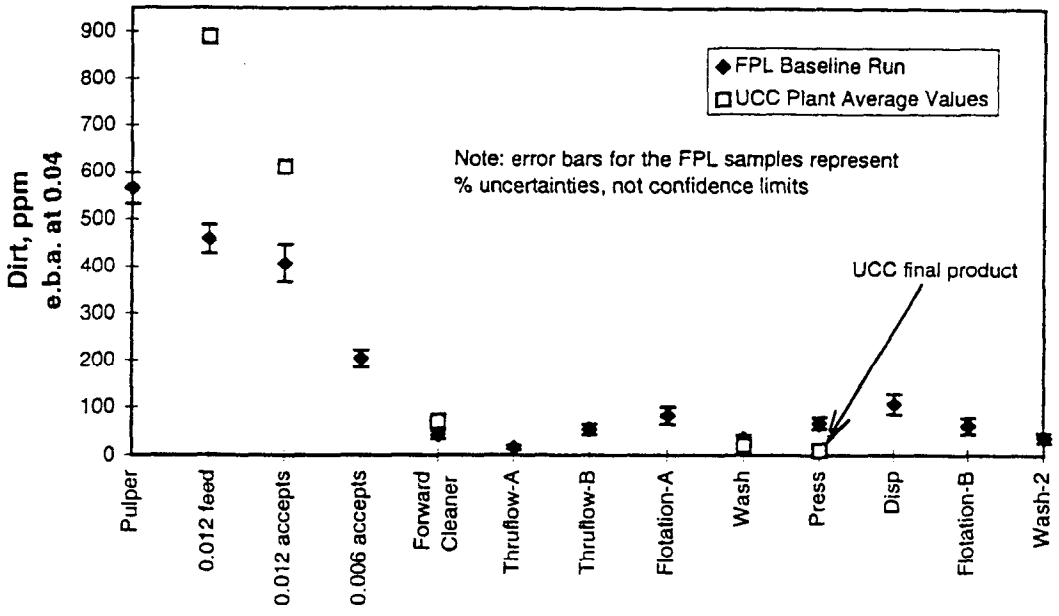

Figure 7 - FPL Pilot Baseline Run: Dirt Profile as Measured at UCC

VI. FPL Trial - Conclusions

A number of key conclusions can be drawn from the pilot recycling trial performed at the Forest Products Laboratory in December 1997.

- The trial objective of assessing the current USPS pilot PSA recycling protocol relative to commercial recycling operations was met and the FPL protocol is an accurate representation of commercial operations.

- The high consistency batch pulper employed by the FPL generates stickies of comparable size to full scale commercial repulpers. Thus the use of the FPL pilot protocol to assess the recyclability of new generation pressure sensitive adhesives provides a realistic simulation of a commercial repulping process.

- With respect to screening, the Voith pressure screens currently used at the FPL were found to be representative of commercial operations in terms of PSA screenability. Conventional stickies exhibited extrudable characteristics, while reformulated adhesives proved highly screenable:

- Despite the calculated 94+% dirt removal efficiency, the FPL pilot facility proved less effective than the UCC commercial facility at removing dirt, The poorer FPL efficiency is primarily attributed to inadequate ink detachment due to the absence of kneaders, These efficiency calculations show that removal efficiency per se is not a good measure of specific contaminant recyclability; true recyclability must be quantified by indexing an absolute particle measurement with background measurements.

VI. Recommendations

The USPS Environmentally Benign Stamp program continues to show excellent promise for development of recyclable pressure sensitive adhesives and support of that program by industry is highly recommended. This support will include providing technical guidance and recommendations as the program moves into full scale PSA stamp conversion. The most pressing issues regarding this. final phase is to establish a suitable dirt count criteria consistent with recycling industry requirements. Fiber yield and PSA seeding levels should also be addressed. Based on the results from this baseline study, Union Camp, as well as other major producers of recycled paper products, is considering a full scale USPS PSA stamp recycling trial in their commercial facility. That type of commercial trial will provide a definitive test of successful PSA reformulation to a more recyclable adhesive.

VI. References

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