CHELSEA CENTER FOR RECYCLING AND ECONOMIC DEVELOPMENT

UNIVERSITY OF MASSACHUSETTS

Technical Report #9

Erving Paper – Dispersion Pilot Project

March 1998

180 Second Street Chelsea, Massachusetts 02150 Tel: (617) 887-2300 • Fax: (617) 887-0399

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Erving Paper – Dispersion Pilot Project

Project Manager: Thomas Newton, Erving Paper
Trial Engineer: Craig Calvert, Beloit Corporation

Chelsea Center for Recycling and Economic Development

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1. ABSTRACT

Erving Paper has recently begun exploring the possibility of installing a Kneader to improve the overall efficiency of their deinking system. They are also looking at using a sodium hypochlorite (or hypochlorite) bleaching stage to control and stabilize the color and brightness of their final product. The payback on these investments would be justified by the ability to process a lower quality furnish and still produce a tissue of equivalent or better quality. Currently the mill recycles a furnish mix of: 40% Coated Book, 40% Colored Ledger, 11% Colored Register, 6% Mixed Office Waste (MOW), and 3% Groundwood. In the future they would like to increase the percentage of MOW in the furnish mix because it is much lower in cost than Coated Book.

In an effort to reduce the risk of investment involved with this project, a pilot scale trial was performed at the Beloit Research & Development Center. The objective of this trial was to process Erving Paper's specific furnish mix through a deinking system similar to their current system, and evaluate the effect of kneading and bleaching on final pulp quality. Erving designated a furnish mix of 50% MOW, 40% Coated Book, and 10% Glossy Coated Book for this trial. The pilot plant layout was as follows: Helidyne Pulper, High Density Cleaner, Fine Screen, Posiflow Cleaners, Flotation, Uniflow Cleaners, Dynamic Washer, Screw Press,
Kneader, Post Flotation, Post Washing, and Final Press. Reductive bleaching side trials were performed in the Kneader. The trial was designed in this manner to simulate the current mill operation and evaluate the benefits of adding kneading, bleaching, post flotation, and post washing.

The test results from the pilot trial are very encouraging. For a furnish containing a significant amount of "stickies" and dirt, the final pulp had only 69 ppm TAPPI Dirt (> 225 μ) and a sheet brightness of 81 GE. The Kneader dispersion unit and hypochlorite bleaching stage are the key operations for achieving these impressive dirt and brightness levels. The overall ash reduction across the system was 94%. The two loop system also reduced the "stickies" content by 99%. In general, the results show the typical trends seen in similar deinking systems. This trial was successful in demonstrating that Erving's furnish can be deinked using Beloit technology to give a quality final product. A summary of results is in the table below.

Sample Location	Freeness (CSF)	Ash Content (%)	Pad Brightness (GE)	Stickies (mm^2/kg)	Total Dirt (> 50 u)	Sub-TAPPI Dirt (50 - 225 u)	TAPPI Dirt (> 225 u)
Dump Chest	255	17.3	56.7	9148	972 ppm	563 ppm	409 ppm
Kneader Press Cake (4 HpD/ton)	480	2.9	69.8	217	733 ppm	426 ppm	307 ppm
Kneader Out (4 HpD/ton)	535	2.8	68.7	123	257 ppm	184 ppm	73 ppm
Sidehill Thick Stock (No Hypo)	-----	1.0	71.8	-----	174 ppm	92.4 ppm	81.6 ppm

2. BACKGROUND

High consistency pulp dispersion has the potential to lower wastepaper furnish costs, increase post-consumer recovered office paper usage, and increase optical and physical properties of recycled tissue. A large and somewhat risky investment in capital would be required to test this proposal at mill scale. This hypothesis will be tested at pilot scale to determine the economic feasibility of the project. If successful, the risk of a mill trial will be significantly reduced, leading to increased use of post consumer fiber, and improved optical and physical qualities.

3. OBJECTIVE

The objective of this trial was to simulate a deinking system to process Erving Paper's specific furnish mix and evaluate the performance of the Kneader and post-dispersion unit operations. Erving also wanted to explore the benefit of using the Kneader as a mixer for a hypochlorite bleaching stage. The trial was designed in this manner to provide input to key areas in a full scale system.

4. MATERIAL

Thirteen bales of wastepaper, weighing a total of 8.3 air dried (AD) tons, were delivered to the Beloit Research Center from Erving Paper. Four AD tons of this furnish (6 bales) were categorized as Mixed Office Waste. Three and one half AD tons of the furnish (6 bales) were categorized as Coated Book. The remaining 0.8 AD tons of furnish (1 bale) were classified as Glossy Coated Book. Thus, the furnish mix processed for this trial was as follows:

50% Mixed Office Waste (MOW)
40% Coated Book (CB)
10% Glossy Coated Book

The hypochlorite bleach and Betz D1235 surfactant, which are both currently being used in the Erving Mill process, were supplied by the customer. The caustic used for pH control was supplied by the Beloit Research Center. The clarification polymers were supplied by Cytec.

5. PROCEDURE DESCRIPTION

The system block diagram is shown in Appendix A. The following is a description of the procedures used in the trial:

Batches of 900 bone (oven) dry (bd) pounds (408 bd kg) were pulped for 20 minutes at 110 ^{o}F (43 ^{o}C), with a target pH of 9.5, and a consistency of 15%. The following chemicals were added to the pulper: sodium hypochlorite (1.52 lbs/ton), Betz D1235 surfactant (0.5 lbs/ton), and caustic soda (NaOH) to maintain the target pH of 9.5. These are the same chemical addition rates the Erving Paper mill currently uses in their pulper. The customer's specific furnish mix of 50% MOW, 40% CB, and 10% Glossy CB was weighed accordingly in the drop box located above the pulper. After the proper amount of dilution water was added in the pulper, the bottom doors on the drop box opened and the pulper rotor ramped up as the stock fell into the pulper. The chemistry was then added over a period of three minutes. At the end of the pulping cycle, dilution water was added to bring the consistency of the pulp to approximately 5.0%, before being processed through the BelPurge.

Following the pulping cycle, the batches of stock were gravity fed to the BelPurge. In the BelPurge, large rejects such as staples, glass, and large pieces of plastic were rejected to a dump box. The accepted stock was pumped directly to the Dump Chest. The BelPurge was quite capable of handling the amount of debris in this furnish. The two bladed rotor was very efficient at clearing the extraction grate without significant degradation to the gross contaminants.

The High Density Cleaner (HDC) was fed directly from the Dump Chest at a target consistency of 3.2%. The pressure drop across the HDC was 26 psi (179 kPa). Elutriation water was set at a flow rate of 2.0 gpm (7.6 lpm) to minimize the fiber loss in the rejects. The HDC accepts were fed directly to the coarse screen. The cleaner rejects were purged on an intermittent basis: a five second purge every 1200 seconds. A large portion of the box staples and grit were removed by the HDC.

The Fine Screen was operated at an inlet pressure of 30 psi (207 kPa) and a consistency of 3.2%. The S-rotor was run at a speed of 1020 rpm and pulled 49 hp (36 kW). The pressure drop across the unit was 3.9 psi (27.0 kPa). The screen accepts were piped to go to the Posiflow Feed Tank. The rejects were purged on an intermittent basis to the rejects handling system: a three second purge every 60 seconds. The 0.006 in.(0.15 mm) slotted basket did an excellent job at concentrating “stickies” particles and small plastics into the rejects stream.

One primary bank followed by a single secondary bank of Posiflow cleaners was used for heavyweight contaminant removal. Four cleaners were in operation in the primary bank with one cleaner in operation in the secondary bank. The feed pressure to the primary bank was 35 psi (241.5 kPa) with an accept pressure of 11 psi (75 kPa). The feed pressure to the secondary bank was 30 psi (207 kPa) with an accept pressure of 11 psi (75 kPa). The accepts from the primary pass went to the PDM (pressurized deinking module) feed tank. The primary rejects fed the secondary pass. The accepts from the secondary pass were piped back to the primary Posiflow feed tank. The secondary rejects, which contained a high concentration of ink and dirt specks, were sent to the rejects handling system.

The PDM stage was fed at 400 gpm (1515 lpm) and 1.0% consistency. The flotation cell was operated at an inlet pressure of 39 psi (269 kPa). Process air was injected at a rate of 24 scfm to maintain a gas/liquid ratio close to 0.5. Betz D1235 surfactant (fatty acid) was added in the pulper at a rate of 0.5 lb/ton to assist the flotation process. 50% percent of the accepts flow was recirculated back to the PDM feed tank to simulate a total of two passes of flotation. The remaining 50% of the accepts were sent to the Uniflow cleaner feed tank. The concentrated inks and dirt particles in the rejects stream were removed under pressure at a rate of 1.8% by volume, and sent to the rejects handling system.

A single, primary bank of Uniflow cleaners was used for lightweight contaminant removal. Six cleaners were in operation with a pressure drop of 20 psi (138 kPa). The feed pressure to the cleaners was 30 psi (207 kPa) with an accept pressure of 10 psi (69 kPa). The Uniflow accepts were piped to the

Dynamic Washer feed tank while the rejects flowed by gravity to the clarifier feed tank. The Uniflow Cleaners removed a significant portion of the "stickies" and plastics from the stock.

The Dynamic Washer was operated with a 13:87 hydraulic split (13%Washed Stock:87%Filtrate) to bring the consistency of the stock to approximately 3.5%. This washing removed the majority of ash and fines in the from the incoming stock. The feed pressure to the unit was 30 psi (207 kPa) with a pressure drop of 0.8 psi (5.5 kPa). The bump rotor was run at a speed of 1180 RPM. The thick stock was piped to a tank which fed a 12 inch (305 mm) Pressmaster horizontal screw press for more thickening prior to dispersion. The washer filtrate was sent to the DAF (dissolved air flotation) feed tank for clarification.

Prior to kneading, the stock was thickened to above 35% consistency in a horizontal screw press. The filtrate from the screw press was piped directly to the DAF feed tank. The press cake was conveyed to the Kneader inlet. Neither chemistry nor steam was added in the Kneader for the main body of this trial. Samples were taken across the Kneader at two separate power levels, 2 HpD/ton and 4 HpD/ton. Samples were taken across the deinking system while the Kneader was operating at 4 HpD/ton. After the system samples had been collected, two bleaching trials were carried out in the Kneader with 4 HpD/ton of power being applied to the fiber. Steam was not added to the Kneader for these trials. The bleaching trials were performed at the operating temperature of the Kneader, which was 145^{o}F (63^{o}C). For the first bleaching trial, sodium hypochlorite was added at a rate of 1.5% to the stock entering the Kneader. The unit reached equilibrium after 40 minutes and samples of the unbleached Kneader Feed and bleached Kneader Out were collected. The second bleaching trial utilized Morton's DBI (Direct Borol Injection) process. This DBI process is discussed in further detail in Appendix C. After the kneading operation the stock was diluted down to approximately 4.0 % consistency and pumped to the Post Flotation Feed Tank.

The post PDM flotation cell was fed at 300 gpm (1136 lpm). The flotation cell was operated at an inlet pressure of 25 psi (172 kPa). Process air was injected at a rate of 24 scfm to maintain a gas/liquid ratio close to 0.5. Surfactant addition was not needed in the second loop of the system. 50% percent of the accepts flow was recirculated back to the PDM feed tank to simulate a total of two passes of flotation. The remaining 50% of the accepts were sent to the Sidehill Washer feed tank. The concentrated inks and dirt particles in the rejects stream were removed under pressure at a rate of 1.8% by volume, and sent to the rejects handling system.

The Sidehill Washer was fed at a flowrate of 142 GPM (538 lpm). The thick stock rolled off of the Sidehill at 6.0% consistency and was pumped to the Final Press feed tank. The filtrate from the Sidehill flowed to the DAF feed tank via gravity.

A 12 in. (30.5 cm) horizontal screw press dewatered the stock before it was collected and sent to landfill. The thick stock reached a consistency greater than 40.0% and was conveyed into a dumpster to be removed. The filtrate from the final press was piped directly to the DAF feed tank.

The Beloit BelAire dissolved air flotation unit was incorporated into the system to clarify the Kneader Press filtrate, Dynamic Washer filtrate, Final Press filtrate, and Uniflow Cleaner rejects. The filtrate streams to be clarified are collected and mixed in a single tank that feeds the clarifier unit. The Uniflow rejects are collected in a separate standpipe which is piped in line to the clarifier feed pump. The clarification rate was set at 100% for the entire system underflow. The dual polymer clarification chemical program was supplied by Cytec Industries Inc. The coagulant (Cytec 577C) was added at a rate of 16 ppm. The flocculant (Cytec AF 128+) was added at a rate of 7 ppm.

6. RESULTS & DISCUSSION

The trial results are given in Appendix B, Tables 1, 2, and 3.

6.1 Furnish

The MOW/Coated Book furnish used for this trial was shipped directly from Erving's mill storage. The overall quality of this furnish was typical of PS-37 grade MOW and PS-43 grade Coated Book. The furnish blend processed in this trial was 50% MOW, 40% Coated Book, and 10% Glossy Coated Book. The test results on the Dump Chest sample show a freeness of 255 CSF (Canadian standard freeness), which is typical for this furnish mix. The high ash content of 17.3% is a result of the fillers and coatings from the Coated Book Furnish. The sheet brightness of 66.5 GE was in the brightness range expected for this quality of furnish. The Hunter L, a, b values indicate there was little colored paper in the raw material. Observations of the pulper loading operation during the trial also support that there was a low content of colored paper in this furnish. The results show this furnish contained a significant amount of "stickies" (9148 mm^2/kg). The image analysis data given in Appendix B, Table 2, show the dirt content of the samples taken for this trial. The Dump Chest had a Total Dirt (>50 μ) content of 972 ppm and a TAPPI Dirt (>225 μ) of 409 ppm. Overall the Dump Chest results were typical of this furnish blend.

6.2 First Deinking Loop

The first loop of deinking operations performed well. The test results on the Dynamic Washer Thick Stock sample show the freeness of the pulp increased to 515 CSF. This is directly caused by the removal of ash and fines during the PDM flotation and Dynamic Washing operations. The ash content of the stock was reduced by 82.1% in the first deinking loop, which led to a Dynamic Washer Thick Stock ash content of only 3.1%. The removal of ink and ash also resulted in a 6.4 point GE increase in sheet brightness across the first deinking loop. The brightness of the Dynamic Washer Thick Stock jumped to 72.9 GE. The Hunter L, a, b values were also affected by the deinking operations. The lightness of the stock ('L' value) increased by 5.4 points and the 'b' value increased to 4.15. The "stickies" content was reduced by 94% through the front part of the system, leaving only 540 mm^2/kg in the Dynamic Washer Thick Stock. Overall the first loop of deinking equipment was very effective in improving the quality of the stock.

6.3 Kneading

The Kneading operation is historically performed at a consistency above 30.0%. The Kneader consistencies during this trial ranged from 33.6 to 37.3%. The fiber to fiber rubbing action facilitates the detachment of ink particles from the fibers and reduces their size. This operation does not separate the dirt/ink particles from the stock. The slow, methodical churning of the Kneader (compared to the Diskperser) also has a tendency to induce curl to the fibers. This in turn decreases the overall strength, but increases the softness, or bulk, of the fibers.

The main objective for including a dispersion unit in a recycling system is to reduce the size of the remaining contaminant particles in the stock. For this trial the Kneader was run at two different power levels: 2 HpD/ton and 4 HpD/ton. As expected, the results show the Kneader is more effective at breaking contaminants down when higher levels of power are applied to the fiber. The image analysis results (Appendix B, Table 2) show the power level of 2 HpD/ton reduced the Total Dirt (>50 μ) by 53.6%. When the power level was increased to 4 HpD/ton the Total Dirt (>50 μ) reduction increased to 64.9% and the TAPPI Dirt (>225 μ) reduction improved from 60.4% to 76.2%. The addition of hypochlorite in the Kneader (at 4 HpD/ton) increased the dirt reduction to over 70% in all three size categories. The TAPPI Dirt (>225 μ) reduction reached 91.0%, which gave a TAPPI Dirt (>225 μ) count of 27 ppm exiting the Kneader. The addition of hypochlorite improves the overall dirt reduction through the Kneader because it actually bleaches some of the dirt particles. These bleached particles are not detected by the Image Analysis scanner. The “stickies” results across the Kneader are inconclusive. The reduction in “stickies” at 2 HpD/ton is 73%. When the power level was increased to 4 HpD/ton there was no reduction in “stickies,” with or without bleach being added to the Kneader. This is probably due to the fact that we have not found a “stickies” test procedure that gives repeatable results at low populations of “stickies.” Therefore we cannot comment on the reduction of “stickies” across the Kneader. Overall, the Kneader was effective in size reducing the remaining contaminants at all power levels.

6.4 Post Dispersion Flotation and Washing

The results show the second deinking loop was operated at a higher consistency than expected. The PDM operation was run at 2.0% consistency, which is too high for flotation to be effective. The image analysis data reflects this. There is very little reduction in dirt content. The flotation stage only removed 39% of the Sub-TAPPI Dirt (50 - 225 μ), from 184 ppm Kneader Out (4 HpD/ton) to 113 ppm Post PDM Accept. The washing stage following flotation did not remove any significant amount of dirt. The results do show the post flotation and washing stages removed some ash. The final ash content of the stock leaving the system was only 1.0%, resulting in a 94% reduction in ash across the entire system. The freeness of the stock also increased considerably across the system, from 255 CSF at the Dump Chest to 590 CSF in the Post PDM Accepts. Overall, a post dispersion deinking loop operated at the proper conditions should remove the majority of the dispersed inks/dirt and increase the brightness of the stock.

6.5 Bleaching

Pilot Plant Bleaching

A key factor when operating in the high consistency (25-30%) bleaching region is the efficiency of mixing the bleach solution with the pulp. High consistency kneading is found to be an effective method of imparting fiber to fiber contact for the mixing of chemicals. The Maule Kneader, used in this trial for dispersion of contaminants, also performed as an efficient high consistency bleach mixer. Sodium hypochlorite was introduced at the Kneader inlet at a rate of 1.5% (based on available chlorine on oven dry fiber). The Kneader has a retention time of 20 minutes. Steam was not added to the Kneader, but the operating temperature for bleaching was 145°F. After Kneader bleaching the pulp was diluted for post flotation and washing operations.

The results showed a two point gain in sheet brightness with the addition of hypochlorite in the Kneader. The system brightness gain with hypochlorite is 8.4 points after post flotation and washing operations. The final deinked pulp brightness is 81.1 GE. Hence this trial has demonstrated the Kneader could be used as a hypochlorite bleach mixer to gain approximately eight points in brightness after post deinking operations.

The color data is given in Appendix B, Table 1. The color is measured by the Hunter L,a,b system. White to black, which is "lightness" to "darkness", is represented by "L"values from 0% (black) to 100% (white). The chromaticity is represented by the "a" values from green (-a) to red (+a) and the "b" values from blue (-b) to yellow (+b). The lightness value (L) increased from 88.1 to 91.6 and the "b" (blue-yellow) value decreased from 4.2 to 2.6 after sidehill washing. This shows that hypochlorite is capable of stripping the color and improving the lightness of the pulp. However, a good washing step is required to see the benefit of hypochlorite bleaching. This washing step also reduces any brightness reversion, a decrease in brightness often caused by yellowing of the pulp due to caustic or other influence.

Laboratory Bleaching

Laboratory bleaching of the Kneader Inlet pulp sample was carried out to study the effect of various charges of hypochlorite on bleach response. This work was performed to optimize the usage of sodium hypochlorite. Sodium hypochlorite charges of 1.0%, 1.5%, and 2.0% were applied under the identical operating conditions of the Kneader (20 minute retention time and 145°F temperature) except for the consistency of bleaching. The laboratory bleaching was carried out at 10% consistency to facilitate the mixing of bleach solution. This was due to the lack of a high efficiency, high consistency mixer in the lab. The laboratory bleaching results showed the Maule Kneader is an excellent high consistency mixer. This is verified by the fact the bleach response in the pilot plant is similar to that of the laboratory bleaching. The pilot plant bleaching gained approximately eight points in brightness with post flotation and washing, whereas the laboratory bleaching showed a gain of 7.5 points.

The comparison of various charges of hypochlorite showed that even at 1.0% hypochlorite level, the maximum attainable brightness gain was reached. Increasing the dosages of hypochlorite beyond 1.0% did not show any significant improvement in the bleaching response. The lightness of the pulp ('L' value) increased in all three laboratory bleaching studies. But the "b" value of the laboratory bleached pulps was higher than the pilot plant post-deinked pulp. This could be due to the lack of a flotation operation on the laboratory bleached pulps.

Direct Borol Injection Bleaching

Direct Borol Injection (DBI) bleaching is regularly used in European mill installations. A DBI bleaching trial was run in the Kneader at the end of the kneading trial by Morton International Inc. A 0.4 point gain in GE pad brightness was achieved across the Kneader using the DBI process. Samples taken for bench scale laboratory bleaching show a 3.6 point gain in GE pad brightness. The pilot plant bleaching may have been hampered because of residual hypochlorite in the Kneader. Hypochlorite is an oxidative bleach chemical and will neutralize the effectiveness of DBI, which is a reductive bleach process. The results of the DBI bleaching trials are discussed in further detail in the analysis written by Morton, included in Appendix C.

7. CONCLUSIONS

1. The Kneader is effective in reducing the size of contaminant particles.
2. The Kneader efficiency increases when the power applied to the fiber increases. At 2 HpD/ton the Total Dirt (> 50 μ) was 53.6%. When the power was increased to 4 HpD/ton the dirt reduction improved to 64.9%. The addition of hypochlorite bleach at 4 HpD/ton increased the Total Dirt (> 50 μ) reduction to 78.3%.
3. The Maule Kneader is an efficient bleach mixer. This is shown by the fact that the pilot plant results are similar to the laboratory bleaching studies.
4. The laboratory bleaching studies at various hypochlorite charges show that a 1.0% hypochlorite charge is adequate to bleach the pulp to its optimum brightness level. Increasing the hypochlorite charge beyond 1.0% did not show any significant improvement in the bleaching response of the pulp.
5. A minimum of six points gain in brightness can be achieved at 1.0 % hypochlorite charge. The final brightness of the laboratory bleached pulp was 78 GE sheet brightness, with the color values of 91.2 lightness (L) and 4.5 "b" value.
6. The first deinking loop operations performed well in improving the overall quality of the stock.

The trial results show that the tested system configuration can produce a high quality deinked pulp. Though the furnish contained a significant amount of "stickies" and dirt, the final pulp had only 69 ppm TAPPI Dirt (> 225 μ) and a sheet brightness of 81.1 GE. The Kneader dispersion unit and hypochlorite bleaching stage are the key operations for achieving these dirt and brightness levels. This trial was successful in demonstrating that Erving Paper's furnish can be deinked using Beloit technology to give a quality final product.

8. TRANSFERABILITY

The information obtained in this trial is transferable to any paper mill interested in lowering their raw material costs by downgrading to a lower quality furnish. This trial was performed with a white grade furnish mix of 50% MOW and 50% Coated Book, but the general conclusions can be applied to most paper recycling processes.

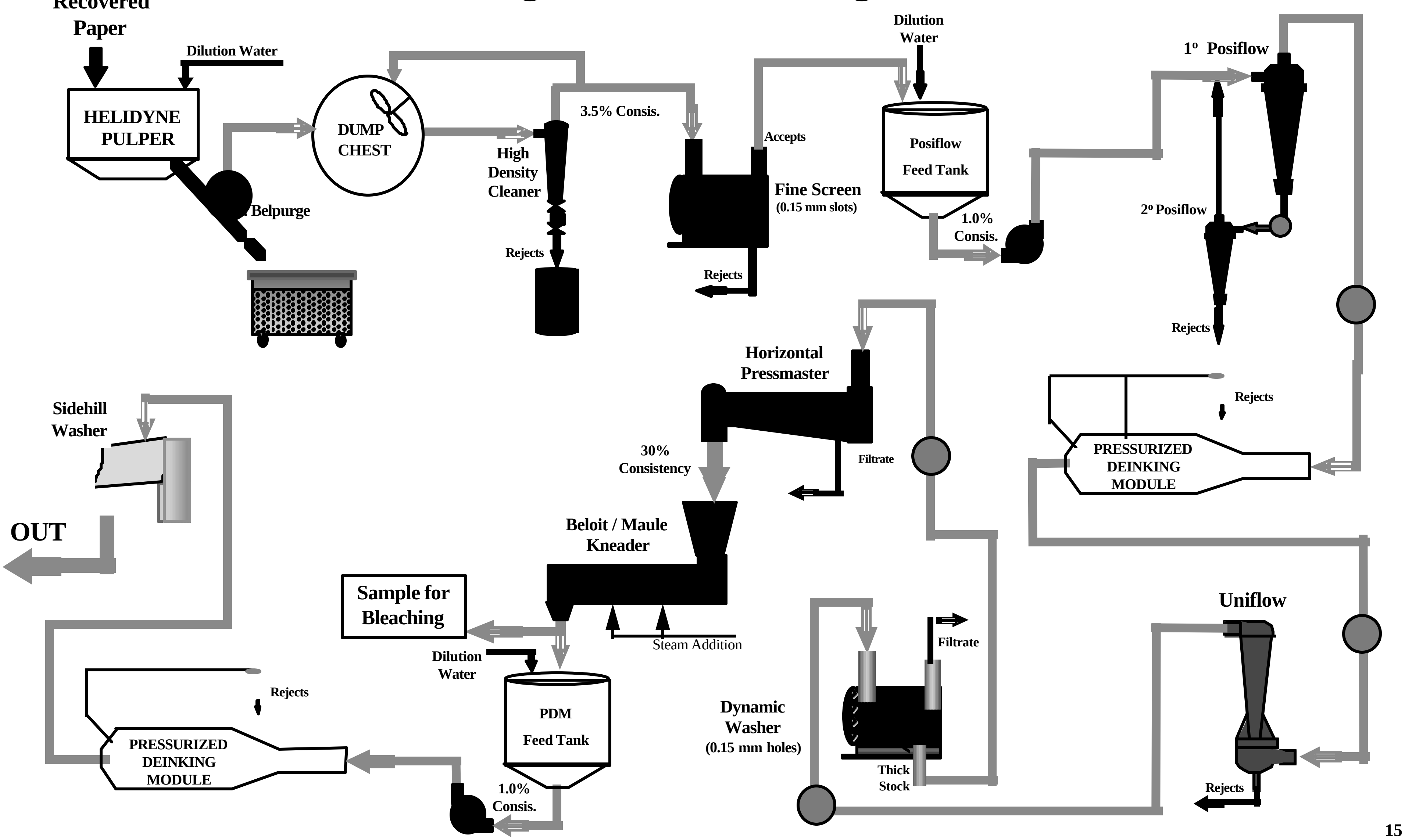
9. FUTURE WORK

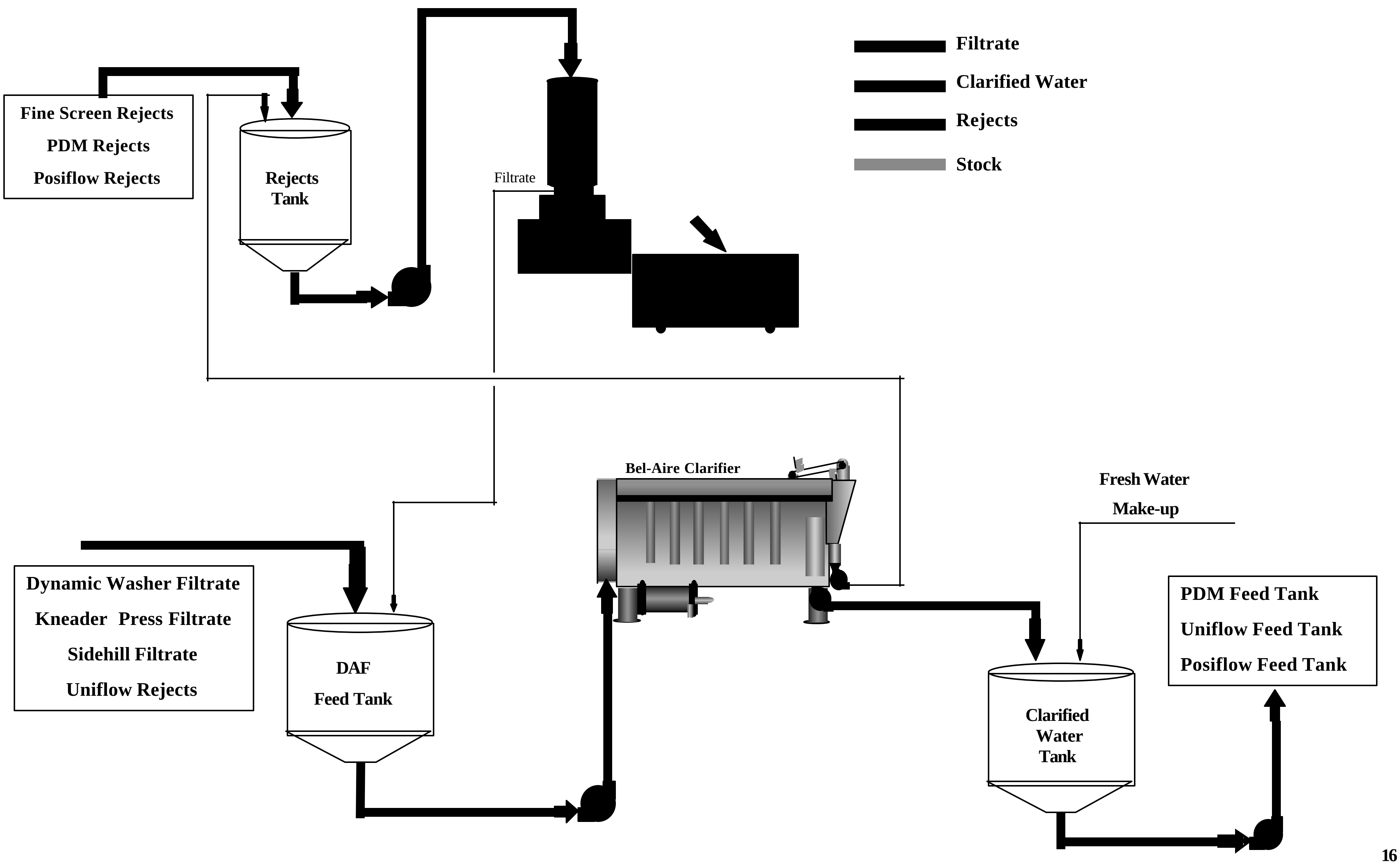
The pilot trial results show the Kneader is a viable operation in the white grade recycling process. The next step would be to run a mill scale trial with the Kneader to determine its impact on the final qualities of the product and identify the levels of lower grade furnishes that can be tolerated.

Appendix A

Block Diagram

Erving Trial Block Diagram





Filtrate
Clarified Water
Rejects
Stock
Fine Screen Rejects
PDM Rejects
Posiflow Rejects
Rejects Tank
Filtrate
Bel-Aire Clarifier
Fresh Water
Make-up
Dynamic Washer Filtrate
Kneader Press Filtrate
Sidehill Filtrate
Uniflow Rejects
DAF
Feed Tank
Clarified Water Tank
PDM Feed Tank
Uniflow Feed Tank
Posiflow Feed Tank
16

Appendix B

Trial Results

Table 1

Trial Results

	Consistency	Freeness (CSF)	Ash Content (%)	Pad Brightness (GE)	Sheet Brightness (GE)	L	a	b	Stickies (mm^2/kg)
Dump Chest	3.6	255	17.3	56.7	66.5	82.7	-0.1	1.9	9148
Dynamic Washer Thick Stock	3.7	515	3.1	69.8	72.9	88.1	-0.2	4.2	540
Kneader Press Cake (2 HpD/ton)	37.3	465	2.1	70.1	-----	-----	-----	-----	309
Kneader Out (2 HpD/ton)	36.9	515	2.2	69.6	72.5	88.5	-0.3	5.0	82
Kneader Press Cake (4 HpD/ton)	37.0	480	2.9	69.8	-----	-----	-----	-----	217
Kneader Out (4 HpD/ton)	36.8	535	2.8	68.7	72.6	88.4	-0.5	4.9	123
Kneader Press Cake (4 HpD/ton - 1.5% Hypo)	35.6	485	2.7	70.5	-----	-----	-----	-----	113
Kneader Out (4 HpD/ton - 1.5% Hypo)	33.6	380	2.8	69.8	74.6	90.2	-1.1	5.7	116
Post PDM Accept	2.0	590	1.3	69.1	72.1	88.4	-0.3	5.2	52
Sidehill Thick Stock (No Hypo)	-----	-----	1.0	71.8	71.8	88.4	-0.5	5.5	-----
Sidehill Thick Stock (1.5% Hypo)	6.2	-----	-----	79.9	81.1	91.6	-1.0	2.6	-----
Kneader Out - 1.0% Hypo (4 HpD/ton)	-----	-----	-----	79.9	78.1	91.2	-1.4	4.5	-----
Kneader Out -1.5% Hypo (4 HpD/ton)	-----	-----	-----	80.9	79.5	91.8	-1.5	4.2	-----
Kneader Out - 2.0% Hypo (4 HpD/ton)	-----	-----	-----	80.8	79.8	91.8	-1.3	3.9	-----

Table 2

Image Analysis Results

	Detection Level	Total Dirt (> 50 *1*)	Sub-TAPPI Dirt (50 - 225 *1*)	TAPPI Dirt (> 225 *1*)	Total Dirt Reduction (> 50 *1*)	Sub-TAPPI Dirt Reduction (50 - 225 *1*)	TAPPI Dirt Reduction (> 225 *1*)
Dump Chest	99	972	563	409	-----	-----	-----
Kneader Press Cake (2 HpD/ton)	124	670	263	407	-----	-----	-----
Kneader Out (2 HpD/ton)	127	311	150	161	53.6%	43.0%	60.4%
Kneader Press Cake (4 HpD/ton)	125	733	426	307	-----	-----	-----
Kneader Out (4 HpD/ton)	127	257	184	73	64.9%	56.8%	76.2%
Kneader Press Cake (4 HpD/ton - 1.5% Hypo)	125	808	508	300	-----	-----	-----
Kneader Out (4 HpD/ton - 1.5% Hypo)	126	175	148	27	78.3%	70.9%	91.0%
Post PDM Accept	125	190	113	77	-----	-----	-----
Sidehill Thick Stock (No Hypo)	128	174	92	82	-----	-----	-----
Sidehill Thick Stock (1.5% Hypo)	129	145	76	69	-----	-----	-----
Kneader Out 1.0% Hypo (4 HpD/ton)	127	185	133	52	-----	-----	-----
Kneader Out 1.5% Hypo (4 HpD/ton)	128	204	136	68	-----	-----	-----
Kneader Out 2.0% Hypo (4 HpD/ton)	126	244	131	113	-----	-----	-----

Table 3

DBI Bleaching Results

Beloit Pilot Plant Trial	Pad Brightness (GE)	L	a	b
Screw Inlet	70.3	86.0	0.2	3.2
Kneader In	71.6	86.4	0.1	2.6
Unbleached prior to Hypo or Borol	70.2	86.1	0.1	3.4
Hypo after Kneader	71.2	88.1	-0.5	4.9
Unbleached 20 mins after Hypo	70.3	86.2	0.0	3.3
DBI after Kneader	70.6	86.0	0.1	2.5

Morton Laboratory Bleaching	Pad Brightness (GE)	L	a	b
1.5% Bisulfite	72.3	87.1	0.0	2.8
0.2% Borol 1.5% Bisulfite	73.9	88.2	-0.5	3.0
0.25% Borol 1.5% Bisulfite	73.8	88.1	-0.4	3.0
0.3% Borol 1.5% Bisulfite	72.4	87.2	0.0	3.0

Appendix C

Morton International
DBI Bleaching Analysis

The following is a report submitted by Morton International labs in North Andover, MA. The data used for pad brightness and the L, a, b results are the same data as presented in Appendix B.

Direct Borol Injection Bleaching

When analyzing the following data, the following issues need to be considered:

1) The Kneader was run for approximately 1 hour after the completion of the hypochlorite bleaching trial. This was an attempt to clear the process flow of as much residual hypochlorite as possible, whereas hypochlorite is a very strong oxidizing bleach, and Direct Borol Injection (DBI) is a reductive bleaching process. Residual hypochlorite in the system will cancel the affect of DBI.

2) Samples of both hypochlorite bleach pulp as well as DBI bleached pulp were taken and sent to Morton International labs in North Andover, MA for analysis.

3) Morton Labs conducted bench scale DBI studies on unbleached pulp samples to observe the affects of DBI in optimum conditions.

Table 1

Beloit Pilot Plant Trial Bleaching

	Consistency	pH	Pad Brightness (GE)	L	a	b
Unbleached pulp prior to Hypo or Borol	39.5	8.9	70.2	86.1	0.1	3.4
Unbleached sample 20 mins after Hypo Addition	38.8	8.9	70.3	86.2	0.0	3.3
Hypo bleached sample after Kneader	30.2	8.6	71.2	88.1	-0.5	4.9
Screw Inlet	39.2	8.9	70.3	86.0	0.2	3.2
Kneader Inlet	36.4	8.5	71.6	86.4	0.1	2.6
DBI after Kneader	34.3	8.5	70.6	86.0	0.1	2.5

The effectiveness of the hypochlorite solution can be seen in Table 1 by comparing Sample 1 (unbleached) to Sample 3 (hypochlorite bleached). The hypochlorite solution gave a 1-pt GE brightness gain, however increased the yellowness of the pulp. Yellow, measure by the ‘b’ value, increased 1.5 pts. The increase in ‘b’value suggests the 1.5% hypochlorite addition rate was too high for two reasons. First, hypochlorite is a yellowish bleach, and an overdose of hypochlorite could have contributed to the increase in yellow. Second, the increase in ‘b’ value could suggest alkali darkening. Excess hypochlorite may have actually burned the pulp and handicapped any brightness gain.

The effectiveness of the DBI solution can be seen by comparing Sample 1 (unbleached) to Sample 6 (DBI after Kneader). The DBI solution showed a brightness gain of 0.4 pts GE and a decrease in ‘b’ value by 0.9 pts. These results are below what we would have expected. Either we can attribute the low brightness numbers to the addition of excess hypochlorite during the hypochlorite stage, or from the fact hypochlorite was simply run before DBI. Either way, hypochlorite is a much stronger oxidizer than bisulfite and borol are reducers, so small amounts of hypochlorite could have had an affect on DBI. In anticipation of this problem unbleached pulp was sent to Morton International labs in North Andover, MA for analysis.

Table 2

Morton Laboratory Bleaching Results

	Pad Brightness (GE)	L	a	b
1.5% Bisulfite	72.3	87.1	0.0	2.8
0.2% Borol, 1.5% Bisulfite	73.9	88.2	-0.5	3.0
0.25% Borol, 1.5% Bisulfite	73.8	88.1	-0.4	3.0
0.3% Borol, 1.5% Bisulfite	72.4	87.2	0.0	3.0

Testing Conditions: 10% consistency, temperature: 85^{o}C, Retention: 30 min.

The laboratory results from Graph 2 show the effectiveness of DBI without possible interference from hypochlorite. The optimum dosage rate of 0.2% borol and 1.5% bisulfite gave a brightness gain of 3.6 pts GE and decreased the ‘b’ value by 0.4 pts. The ‘L’ and ‘a’ values of the hypochlorite and optimum DBI bleaches are virtually identical. DBI shows a brightness and ‘b’ value advantage in the lab compared to the hypochlorite tests in the pilot plant.

Summary

The DBI trial at the plant did not perform as expected. DBI is regularly being used in Europe and is an excellent color-stripping agent (the higher the color-content, the better). Based on European experience, the DBI was expected to give a higher GE brightness gain than the 0.4 points seen during the trial. The low trial numbers compared with the positive 3.6 points GE brightness gain seen in the lab lend credit to the possibility of hypochlorite contamination at the trial level. Lab DBI work showed a higher brightness response and lower ‘b’value as compared to hypochlorite bleaching. Further investigation of the effectiveness of DBI at Erving Paper, possibly by an on-site trial, is recommended.