

Papricycle—a mill-proven process for saving bleach plant caustic and steam

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The process is now being used successfully by Weyerhaeuser Canada in the "A" bleach plant of the Kamloops mill to provide a savings of 35% in caustic usage in the E1 stage.

Electrolytic cells produce chlorine and caustic in a fixed ratio. If the market demand for these chemicals does not closely correspond to the electrochemical ratio, there is an immediate upward pressure on the price of whichever chemical is in short supply. The demand for caustic is presently outstripping the demand for chlorine, and the situation is not expected to improve. Therefore, processes which decrease the demand for caustic should lower costs not only by saving caustic but also by helping to maintain the balance in the chlorine-to-caustic ratio.

One method of lessening the demand for caustic is to ensure that the alkaline streams within the mill are used efficiently. Here, we will describe a process—Papricycle—that makes better use of one of these alkaline streams, and we will show how one mill has applied it.

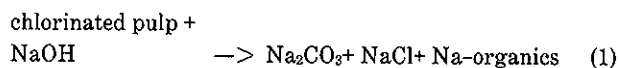
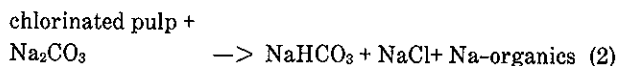
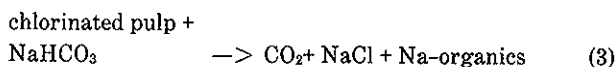
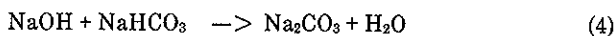
Papricycle—laboratory work

Reactions of different alkalis in an extraction stage

Extraction-stage filtrate is an alkaline stream that has the potential for more efficient use. About 25% of the sodium hydroxide consumed in the E1-stage is converted into sodium carbonate (1), which has been shown to have a positive reaction on chlorinated pulp by decreasing the CE kappa number through a partial extraction of the pulp (2, 3). If extraction-stage filtrate is added to well-washed chlorinated pulp, several reactions can occur. First, any residual sodium hydroxide will be consumed by forming sodium chloride, sodium carbonate, and organic acid salts (Eq. 1). Second, any sodium carbonate (including that formed from the residual sodium hydroxide), will be consumed by forming sodium chloride, sodium bicarbonate, and organic acid salts (Eq. 2). Finally, if there is a

sufficient excess of acidic chlorinated pulp, the sodium bicarbonate formed from the reaction of sodium carbonate will react further, giving carbon dioxide and again sodium chloride and organic acid salts (Eq. 3). Thus, each of the alkali sources can be used to give a useful reaction.

In a normal filtrate recycle process in a bleach plant (direct countercurrent, for example), much of the recycled alkalinity ends up as NaHCO_3 or dissolved CO_2 (Eqs. 2 and 3), which is carried forward with the pulp to the E stage. Unfortunately, NaHCO_3 and CO_2 are acidic to caustic soda and consume it, as shown in Eqs. 4 and 5. The protons stripped from the chlorinated pulp are stored as NaHCO_3 in the liquor and are carried back to the E stage, where they consume caustic. However, the situation should change if the pulp is washed after the addition of the recycled effluent.



Comparison of E-stage effluent recycling procedures

Table I shows the comparison of no recycle, conventional recycle, and recycle followed by washing. These results were obtained with a laboratory-cooked black spruce kraft pulp of kappa no. 27.5. The pulp was chlorinated conventionally and then thoroughly washed with deionized water. In the "no recycle" runs, the pulp was extracted under conventional conditions with different charges of sodium hydroxide. In the "conventional recycle" runs, the chlorinated pulp was brought to 20% consistency and was then diluted to 10% consistency with the effluent from a conventional extraction stage.

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I. The alkali required in an E-stage to achieve a given CE kappa number or brightness with different recycling procedures

Type of E1 effluent recycle	NaOH charge in the extraction stage, % on o.d. pulp	CE kappa no.	ISO brightness, %	
			D1	D2
No recycle	3.0	5.4	81.0	89.5
	2.0	6.1	76.7	...
	1.0	9.0	56.5	84.6
Conventional	3.0	5.5	81.4	89.6
Recycle	2.0	5.8	76.6	87.9
(With no wash)	1.0	8.4	60.7	85.5
Recycle	3.0	5.1	82.2	89.9
Followed by washing	2.0	5.3	81.7	89.6
(Papricycle)	1.0	5.8	79.6	88.7
Unbleached pulp :	Black spruce kraft pulp, kappa no. 27.5.			
C-stage :	5.5% Cl ₂ on o.d. pulp, 45 min at 25°C, 3.5% consistency.			
Papricycle :	5 mL of extraction effluent per gram of chlorinated pulp, 5 min at 60°C, 10% consistency.			
E-stage :	90 min at 70°C, 10% consistency.			
D1-stage :	1% ClO ₂ and 0.55% NaOH on o.d. pulp, 3 h at 60°C, 10% consistency.			
E2-stage :	1% NaOH on o.d. pulp, 1 h at 60°C, 10% consistency.			
D2-stage :	0.5% ClO ₂ on o.d. pulp, 3 h at 60°C, 10% consistency.			
(The extraction effluent used for recycling was produced by extracting the same chlorinated pulp with 3% NaOH on o.d. pulp.)				

II. The effect of several cycles on the results of the Papricycle process

Type of process	Run no.	Source of effluent for recycle	NaOH charge in the extraction stage, % on o.d. pulp		CE kappa no.
Conventional	1	No recycle	3.0		4.3
Papricycle	2	Run 1	2.0		4.3
Papricycle	3	Run 2	2.0		4.1
Papricycle	4	Run 3	2.0		4.0
Conventional		No recycle	2.0		5.2
Conditions as listed in footnote to Table I.					

III. The effect of the temperature and time of contact of the recycled extraction effluent on the CE kappa number

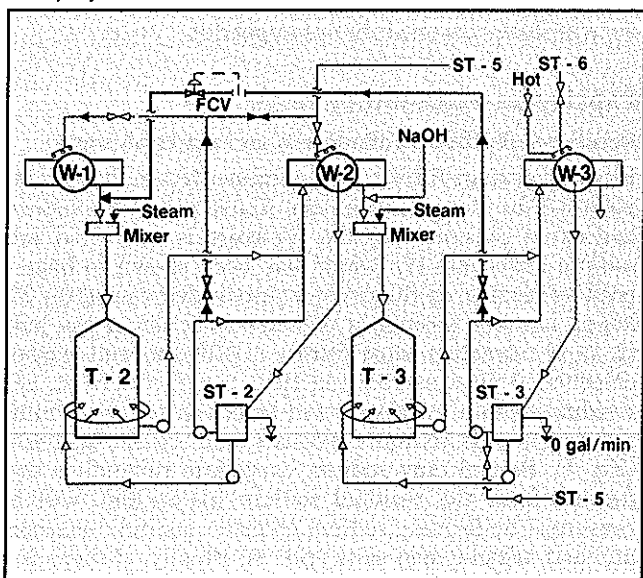
Recycled extraction effluent		CE kappa no.
Temp., °C	Time of contact, min	
60	10.0	3.9
60	5.0	4.1
60	1.0	4.0
60	0.5	4.0
25	0.5	3.9
C- and E-stage conditions as listed in footnote to Table I. (E-stage charge = 2.0% NaOH on o.d. pulp.)		

[This provided 5 mL of recycled effluent for every 1 g of pulp (o.d. basis). This 5 mL/g charge, however, could have been added by displacing the liquor associated with the pulp or simply by diluting to lower consistency.]

The extraction effluent, at 60°C, remained in contact with the pulp for 5 min. Then alkali was added to the mixture, and the extraction was completed. The kappa numbers measured after the CE stages and the brightnesses measured after the D1 and D2 stages of the CEDED sequence were similar in these two sets of experiments. These results agree with those of Histed and Nicolle (4, 5) and Wartiovaara (6, 7), who found that countercurrent recycle did not decrease alkali consumption in the E stage.

In the "recycle followed by washing" runs, the chlorinated pulp was again brought to 20% consistency and diluted to 10% consistency with the effluent from a conventional extraction stage. The extraction effluent, at 60°C, was again allowed to be in contact with the pulp for 5 min. In these runs, however, the pulp was washed before the conventional extraction stage. Recycle followed by washing allowed a target kappa number or a target brightness to be obtained with only 2.0% NaOH in the E1 stage, compared to the 3.0% NaOH required to reach the same kappa number or brightness level in the other examples. This process of E1-stage effluent recycle followed by washing to decrease the chemical requirements in the E1 stage has been called "Papricycle."

1. Papricycle modified extraction



Varying the conditions in the Papricycle process

Table I shows that the relationship between CE kappa number and the intermediate or final brightness is largely unaffected by the type of recycling. Therefore, comparisons of CE kappa number were used to assess whether or not the savings in E1 stage charge could be sustained

over several cycles and to determine how much time is required for the reaction of chlorinated pulp with recycled effluent.

Table II shows that the alkali savings gained in the extractions described in Table I could be maintained when the recycling system approached steady state. In this experiment, the effluent from the first run (a conventional extraction with a 3.0% caustic charge) was used in the second run to partially extract the pulp. After washing, this pulp was extracted with the lower charge of sodium hydroxide, and the effluent was then used to pre-extract in the third run. The levelling off of the CE kappa number after Run 3 to a value lower than that of Run 1 shows that the alkali savings can be sustained as the number of cycles increases.

Table III shows that changes in the time and temperature of the treatment of chlorinated pulp with recycled extraction effluent did not affect the outcome. Decreasing the time of contact from 10 min to 30 s and the temperature from 60°C to 25°C did not change the CE kappa number. This means that the reactions can be done in a pipeline, and no special reaction vessel is necessary.

Papricycle—mill application

There are several ways in which a bleach plant can be modified to use Papricycle. The simplest modification is that applied to a mill which has a six-stage bleach plant and which, by adding oxygen to the extraction stage, has eliminated the hypochlorite stage. As a result of these changes, the original H-stage washer can be repiped for use as the "Papricycle washer." In effect, it will be operating as if it were between the C-stage washer and the E-stage steam mixer.

In a five-stage bleach plant, there are three possible modifications. Two are costly: a new washer can be placed in the sequence between the C and E stages or, if space is a limitation, the C-stage washer can be replaced by a multistage washer to give an extra washing step. Despite the cost of these options, the economics of the process still allow a moderately good return. The best alternative, however, is to use one of the washers from later in the sequence—i.e., the D1-, H-, or E2-stage washer—and bleach with one of the following sequences: CE(XE)D (8), CEX(ED) (8), or CEXnD (9), where X stands for D or H and n represents a neutralization step.

Weyerhaeuser Canada, Kamloops

The first full mill application of Papricycle, at Weyerhaeuser Canada, Kamloops, required the simplest of the available modifications.

The Kamloops "A" mill was built in 1965 and was designed to produce 250 tons of kraft pulp per day, using softwood chips in three batch digesters. The bleach plant used a six-stage sequence, (CD) EHD E D.

In 1972 the much larger "B" mill was added to the mill site, and some major redesign took place. The "A" mill was converted to processing softwood sawdust and shavings by installing two M&D digesters along with another brownstock washer. The sawdust and shavings were cooked to 22 K No. (i.e., kappa no. 33) and were bleached to 90%-plus TAPPI brightness for domestic and export markets using the (CD) EWDED bleaching

sequence. The H stage was eliminated to preserve pulp strength.

By 1987 the production rate in "A" mill had increased to the present average of 320 a.d. metric tons/day, but because of its small size, it had not been worthwhile to install oxygen-alkali extraction. This circumstance was fortunate because it facilitated the installation of the Papricycle step.

The changes made to operate the Papricycle process

Figure 1 shows part of the "A" mill bleach plant. Tower 2 is the original extraction tower, and Tower 3 is the original H-stage tower, which was used only for buffer storage of pulp prior to the trial.

For the first trial, the extraction stage was moved from Tower 2 to Tower 3, which then gave a long retention time in Tower 2 for the Papricycle step. This long retention time was not necessary because the reactions occurring in the Papricycle step are fast (Table III), but it was easiest in this application to keep the tower in use. The time was shortened to some extent by operating Tower 2 at about 50% capacity. The large volume of filtrate from Washer 3 was pumped through a new line to the steam mixer ahead of Tower 2, and the consistency in the tower then fell to about 5%. Washer 2 filtrate was now used for shower water on Washer 1.

With this configuration, an 8-h Papricycle trial was run during July 1987. The first two stages of the bleach plant were shut down to change over, and within 2 h the bleach plant was running again with the Papricycle step. There were no serious problems in switching over or in running the new process. The result was caustic savings of 10–15 kg/a.d. metric ton, although chlorine dioxide usage in Tower 4 went up marginally. This increase in chlorine dioxide usage had been anticipated, because in making the conversion we had eliminated a second wash step from between the E and D stages. The increase, however, was not observed in a later, more lengthy trial, and it shows that Papricycle can have a substantial effect in reducing carryover into the D stage (2).

A longer trial was scheduled for August 1987, and a number of modifications were undertaken. A flow meter and a control valve were installed on the new filtrate line to Tower 2. The shower piping on Washer 3 was modified so that Seal Tank 6 (D2 stage) filtrate went to the top two headers and hot water went to the bottom two. Finally, a pH probe was installed in Washer 2 vat.

After two days on the extended trial, it was decided that the new process was to become permanent. After 11 months of operating experience, the only problem encountered was that the new filtrate line plugged with stock. A check valve has since eliminated this problem.

Startups and shutdowns were found to be no different with Papricycle than they were with the unmodified bleach plant.

Results of using the Papricycle process

Chemical usage

In Table IV, chemical usage data for 6 weeks prior to the start of Papricycle are compared to data at 2 months after using Papricycle. The total active chlorine in the chlorination stage and the chlorine dioxide usage in the

IV. Bleaching chemical usage

	Percent change
Total Cl_2 in C-stage	+2
E1-stage NaOH	-24
D1-stage NaOH	-82
D1-stage ClO_2	-1

D1-stage both remained almost constant, while the extraction stage caustic was reduced by 24% due to Papricycle.

The percentage decrease in caustic usage was less than the 33% savings found possible in the laboratory. However, because of the higher caustic charges used in the mill, the actual amount of caustic saved was larger than in any of the laboratory work. These observations are probably explained by the difference in the quality of washing between the laboratory and the mill.

The percentage savings have now been recognized as higher because part of the extraction-stage caustic charge is made up of "blowdown caustic" from a scrubber which contains sodium hypochlorite rather than sodium hydroxide. Also, the percentage savings have been increased through better control using an automatic pH loop and through better washing caused by replacement of the showers on the chlorination washer. Now the E1-stage caustic usage has been decreased to 65% of the original consumption.

The observed decrease in the D1-stage caustic application was due to the rearrangement of the showers on the extraction-stage washer just ahead of the D1-stage. The D2-stage filtrate was moved from the bottom shower bars to the top, and hot water was moved from the top to the bottom. This saving represents only a small amount of caustic (1 kg/a.d. metric ton).

Operating changes

Extracted brightness is used as a parameter at the mill, and initially a two-point drop in this extracted brightness was observed (Table V). The extracted brightness was affected by the Papricycle-stage pH, with a pH around 6 resulting in a lower extracted brightness. The pH target was raised, and the extracted brightnesses returned to around 36%. The average residual E1-stage pH was maintained at 10.7 throughout this period of evaluation. Table VI also shows that the decreased extracted brightness was paralleled by a decrease in D1-brightness. Again, this was rectified by the change in Papricycle step pH. The final pulp brightness throughout the trial (Table VII) remained constant.

Recycling large amounts of hot filtrate had the potential to decrease steam usage. This was borne out by the results at the mill, where there was an increase of 11°C in the Tower 3 caustic extraction-stage temperature after the Papricycle step was installed. This temperature rise

V. Bleach plant operating data

	Before Papricycle	After Papricycle
Average K No.	22.6	22.5
Extracted brightness, %	36.2	34.3
D1-stage brightness, %	83.6	82.7
E1-stage pH	10.7	10.7
Papricycle-stage pH	...	6.9
Tower 2 temp., °C	77	77
Tower 3 temp., °C	60	71

VI. Effluent properties

	Before Papricycle	After Papricycle
Color, ppm	6240	7800
pH	11.1	9.3
BOD ₅ , ppm	140	270
Na ⁺ , ppm	1360	1260
Monitored over the same time period as in Table V.		

corresponds to a steam saving of 0.43 GJ/ton of pulp. At a cost of \$4.15/GJ, this represents a potential energy savings of \$1.78/a.d. metric ton.

Effluent changes

The bleach plant effluent was monitored over the period of June through October. The color and BOD₅ concentrations increased after the use of Papricycle, whereas the pH and sodium ion concentration decreased (Table VII). The color and BOD₅ concentrations increased because of reduced fresh water usage and greater use of filtrates. The pH and sodium ion concentrations decreased because most of the residual alkali normally going to the sewer was consumed and because the caustic dosage was decreased. Other work done in the laboratory has shown that if the BOD and color are measured on a pulp basis, they do not change.

Pulp property changes

The finished pulp properties were reviewed by comparing the first six months of 1987 with the last 3 months of 1987 (Table VII). There was no significant difference in any of the properties evaluated using the results of over 170 tests.

Cost savings

The chemical cost savings attributed to Papricycle at the Kamloops mill are \$525,000/year for a 325-ton/day line, while the total cost of installing the new process was \$23,000. This cost represents a savings of \$4-5/ton of pulp

VII. Average finished pulp properties

	Before Jan-June 1987	After Oct-Dec 1987
Brightness, % (TAPPI)	91.1	9.10
Dirt, ppm	1.9	2.0
Burst index, ^a kN/g	5.7	5.6
Tear index, ^a mN·m ² /g	8.7	9.1
Tensile index, ^a nM/g	85.8	87.9
Viscosity, mPa·s	14.7	14.3

^aAt 400 mL CSF

produced, with a payback time of 15 days.

The large increase in the Tower 3 temperature during the Kamloops trial shows that there is also a potential steam savings by using Papricycle. If the steam costs \$4/GJ, then every 10°C rise in temperature caused by recycle will save \$1.5/ton of pulp.

Conclusions

Papricycle is a process that works both in the laboratory and in the mill. It is a technology which has been successfully transferred from the laboratory to the bleach plant, and actual caustic savings realized in the bleach plant are similar to the savings predicted in the laboratory.

At Weyerhaeuser Canada, Kamloops, the caustic savings were 35% of the extracted-stage caustic usage, for an annual savings of \$525,000. The total cost of installing the new process was only \$23,000, giving a payback of 15 days.

Operator acceptance has been excellent because the startup was quick and simple and because the operation of the bleach plant was only minimally altered by the introduction of the Papricycle step.

Literature cited

1. Berry, R. M. and Fleming, B. I., J. Pulp Paper Sci. II(6): J176(1985).
2. Berry, R. M. and Fleming, B. I., J. Pulp Paper Sci., published Sept. 1988.
3. Liebergott, N., van Lierop, B., and Bolker, H. I., Transactions Tech. Sect. CPPA 8(1): TR5(1982).
4. Histed, J. A. and Nicolle, F. M. A., Pulp Paper Mag. Can. 74(12): T386(1973).
5. Histed, J. A. and Nicolle, F. M. A., Pulp Paper Can. 75(5): T171(1974).
6. Wartiovaara, I., Paperi Puu 62(5): 319(1980).
7. Wartiovaara, I., Pulp Paper Can. 81(7): T167(1980).
8. Histed, J. A., Pulp Paper Can. 85(6): T156(1984).
9. Allison, R. W. and Johnson, A. P., Proceedings, 1988 CPPA-TS Pacific Coast and Western Branches Meeting, CPPA, Montreal.

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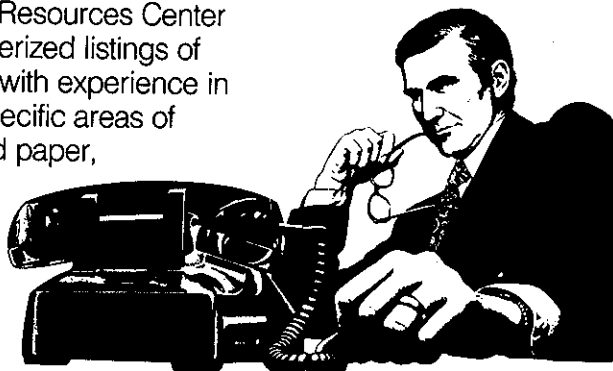
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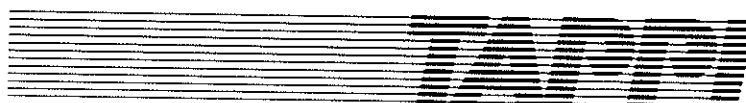
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