Lo-Solids™ pulping: principles and applications

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ABSTRACT

Results from laboratory studies have shown that improvements in pulping performance can be obtained by decreasing the concentration of dissolved wood solids throughout the bulk phase of delignification. This led to the development of a new continuous cooking process: Lo-Solids™ pulping. The objective of the new pulping process is to minimize the concentration of dissolved wood solids throughout the bulk phase of delignification while maintaining, as with other forms of modified cooking, an "even" alkali profile, minimal cooking temperatures, and minimal concentrations of dissolved lignin at the end of the cook. In order to achieve this, use is made of split (or Multiple) extractions, split white liquor additions, and split washer filtrate additions. Cooking profiles are manipulated by altering the relative flows of extraction and of diluent additions.

Application:

In numerous applications it has been found that the new process results in improved pulp strength and viscosity, increased extraction capacity. and enhanced digester washing. Decreases in cooking temperature, cooking chemical requirements, and bleaching chemical requirements have also been cited. Most existing digester systems can be retrofitted to perform Lo-Solids pulping with only minor process equipment modifications.

LABORATORY STUDIES *1, 2* HAVE shown that the dissolved wood solids present in digester cooking liquors cause:

- A decrease in pulp viscosity and pulp tear strength
- An increase in white liquor consumption
- A decrease in pulp bleachability
- A decrease in brownstock brightness
- A decrease in final bleached pulp brightness ceiling.

It was also found that the dissolved wood solids present during the bulk delignification stage contribute significantly to the effects cited above.

Dissolved wood solids refers to the lignin, cellulose, hemicellulose, extractives, metals, and minerals which are removed from wood and dissolved into the surrounding liquor phase. Bulk delignification refers to the cooking which occurs immediately after chips have been impregnated and heated to full cooking temperature, whereas final delignification refers to the last half of cooking.

OBJECTIVES

The results described above led to the development of Lo-Solids™ pulping. The primary objective is to minimize both the *amount* and *concentration* of dissolved wood solids present during bulk and final delignification. As with other forms of modified continuous kraft pulping, it is also necessary to ensure:

- Uniform radial distribution of temperature, retention time, and cooking chemical
- An even alkali profile along the height of the cooking vessel
- Minimal concentrations of dissolved lignin at the end of cooking, and
- Minimal peak cooking temperatures.

Finally, it is important to maintain sufficient concentrations of alkali throughout the bulk and final delignification stages. If conditions arise where the alkali concentration within chips is very low and temperatures are high (i.e., at or near full cooking temperature), then pulp with low viscosity and high rejects may be produced.

Many of these basic objectives are similar to those of modified continuous cooking (MCC®) and extended modified cooking (EMCC®). However, the new process described here aims at decreasing the concentration of *all* dissolved wood solids in *both* the bulk stage and final stages of cooking, whereas earlier modified continuous cooking methods are primarily designed to decrease the concentration of dissolved lignin in the final stage of cooking.

METHODS OF APPLICATION

Dissolved wood solids are removed from the system as they are formed by extracting spent impregnation and/or spent cooking liquors at multiple locations in the vessel(s). In this way, extracted dissolved solids are prevented from entering cook zones either above or below the point of extraction and so the *amount* of dissolved wood solids present in the bulk and final stages of delignification is decreased. Consider the

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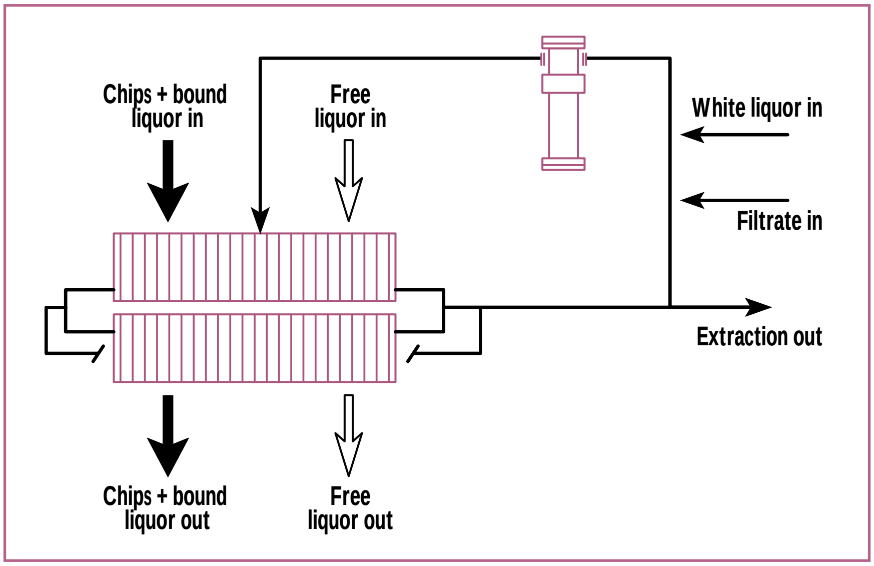
extraction of spent impregnation liquor. During impregnation between 20 and 30% of wood is dissolved. At a production rate of 1000 a.d metric tons/day, for example, this corresponds to between 435 and 650 tons/day of dissolved wood solids in spent impregnation liquor. As much as half of this material can be removed from the system prior to bulk delignification through the use of a post-impregnation extraction (i.e., an extraction prior to the commencement of bulk delignification).

In addition to dissolved wood solids, water and cooking chemical will also be removed from the system at each of the extractions. The amount of water and effective alkali removed at a given extraction will obviously depend on the extraction flow rate and alkali concentration there. Makeup water must be added in order to satisfy system hydraulic requirements. Makeup cooking chemical must be added in order to satisfy downstream requirements for additional cooking. As a result, a combination of white liquor and washer filtrate is added either at or downstream of each extraction point.

Much, but not all of the dissolved solids present at a given location can be removed from the system via extraction. The makeup white liquor and makeup washer filtrate both have significantly lower concentrations of dissolved wood solids than do the remaining digester liquors they are mixed with. The combined makeup flows therefore dilute dissolved wood solids that remain in the system after an extraction. At the same time, addition of the combined makeup flows increases the liquor to wood ratio downstream of a given extraction. A higher liquor to wood ratio helps dilute any additional dissolved wood solids formed during subsequent cooking. Dilution with the combined makeup flows therefore decreases the *concentration* of dissolved wood solids present in the bulk and final stages of delignification.

In summary, the method of application involves extraction of spent liquors followed by makeup and dilution with white liquor and washer filtrate. This extraction, makeup, and dilution sequence is performed one or more times, depending on the configuration of the system in question.



1. Simultaneous extraction, makeup, and dilution in a concurrent heating circulation. Schematic shows a screen section in the digester with external heating circulation and central pipe discharge.

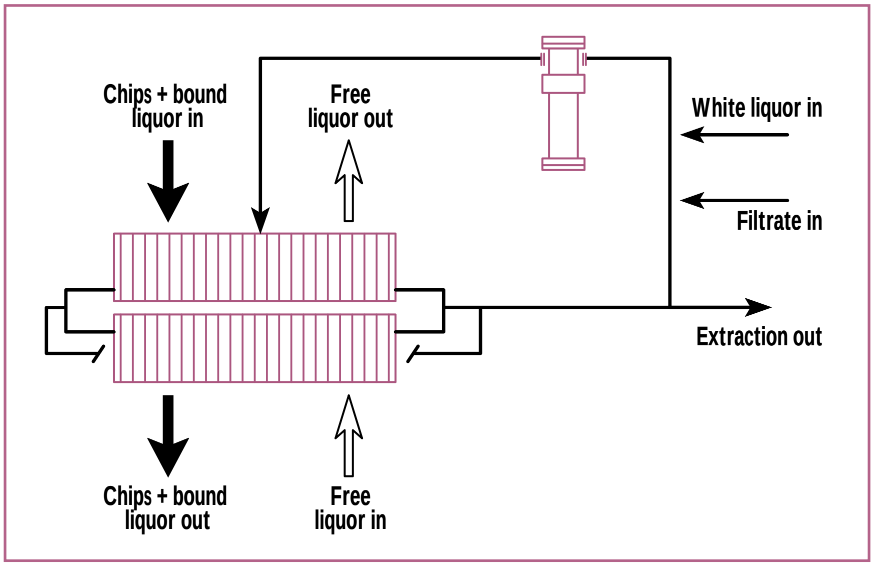
PROCESS LAYOUTS

Multiple white liquor additions, multiple filtrate additions, and multiple extractions can be used in any continuous digester provided that liquor circulation systems are present. The final configuration of a retrofitted digester will depend on the design of existing equipment (i.e., the number and location of circulation screens and central pipe discharges). Process layout will also be determined by factors such as shell dimensions, mill specific objectives, and mill specific process constraints. The principle of extraction followed by makeup and dilution can be applied in either a concurrent or countercurrent digester zone. Extraction followed by makeup and dilution can be affected in three ways; these are illustrated schematically in Figs. 1 through 3.

Method 1

Simultaneous extraction, makeup, and dilution in a concurrent heating circulation. The layout for this method is illustrated in Fig. 1. For this configuration:

- Extraction off the circulation is upstream of the white liquor and washer filtrate addition point.
- Makeup white liquor and filtrate flows are added to the inlet of the heater and then heated to required temperature.
- Preheated white liquor and filtrate are introduced in the center of the digester through the central pipe discharge.
- Cooking chemical and temperature are distributed via a radial displacement (i.e., from the central pipe discharge to the circulation screens at the vessel wall).



2. Simultaneous extraction, makeup, and dilution in a countercurrent heating circulation. Schematic shows a screen section in the digester with external heating circulation and central pipe discharge.

Method 2

Simultaneous extraction, makeup, and dilution in a countercurrent heating circulation. The layout for this method is illustrated in Fig. 2. For this configuration:

- Extraction off the circulation is upstream of the white liquor and washer filtrate addition point.
- Makeup white liquor and filtrate flows are added to the inlet of the heater and then heated to required temperature.
- Preheated white liquor and filtrate are introduced in the center of the digester through the central pipe discharge.
- Cooking chemical and temperature are distributed via (a) a radial displacement *and* (b) countercurrent flow of free liquor in the preceding zone.

Method 3

Extraction followed by downstream makeup and dilution in a split upflow/downflow heating circulation. The layout for this method is illustrated in Fig. 3. For this configuration:

- Extraction occurs at an upflow downflow interface.
- A heating circulation may or may not be used at point of extraction.
- Makeup white liquor and filtrate flows are added to the digester in a downstream heating circulation.
- Preheated white liquor and filtrate are introduced in the center of the digester through the central pipe discharge.
- Part of the combined makeup flows counter-currently upward, and the balance will flow concurrently downward.
- Cooking chemical and temperature are distributed via (a) a radial displacement *and* (b) countercurrent flow of free liquor in the preceding zone.

In most cases, the modifications required for retrofitting this process are minor, usually consisting of external piping and valves of relatively small diameter. Upgrades on peripheral equipment such as heaters, flash tanks, pumps, etc., may or may not be needed depending on the specific application. For retrofits, no modifications are required which would prohibit operation in the pre-existing configuration. As a result, retrofitting is a low risk proposition.

PROCESS REQUIREMENTS AND CONSTRAINTS

White liquor and filtrate

Since there is a limit to the amount of filtrate and white liquor which can be added to the digester, the extraction liquor at each of the extractions should be as low in cooking residual and as high in dissolved solids as possible. Minimizing white liquor application to the feed accomplishes both of these objectives.

In general, both the dissolved wood solids generated and the alkali consumed during impregnation are independent of the initial white liquor application so long as there is a sufficient amount of white liquor present there. Excess white liquor to the feed will increase the impregnation zone's liquor to wood ratio and therefore decrease the concentration of dissolved wood solids in spent impregnation liquor. Any white liquor applied to the feed which is over and beyond the amount consumed in impregnation will remain as residual. Shifting white liquor away from the feed thus results in increased concentrations of dissolved wood solids and decreased alkali residuals for spent impregnation liquor. The amount of dissolved wood solids removed from the system for a given post impregnation extraction flow rate will therefore increase. At the same time, the amount of alkali removed from the system there will decrease.

As mentioned earlier, sufficient concentrations of alkali must be maintained at all locations within the digester. The need to maintain minimum residuals imposes a constraint on both the white liquor charge and the white liquor splits. This also poses a constraint on the amount of filtrate which can be added at any given location in the digester: filtrate will dilute alkali concentrations and so if too much is added it may washout the cook. Other potential constraints on the amount of filtrate addition are heater capacity, flash tank and flash liquor pump capacity, and evaporator capacity. In general, digester extraction capacity and digester column movement *do not* limit total filtrate addition when multiple extractions and multiple filtrate additions are used. Increased extraction capacity and increased filtrate uptake capacity result in improved digester washing.

Heating requirements

Extraction of unheated liquors results in decreased steam requirements. This effect is especially pronounced when extracting spent impregnation liquors prior to reaching full cooking temperature. On the other hand, having to heat extra filtrate to cooking temperature increases steam demand. These two factors have opposite effects on overall steam economy. The net effect will depend on the flow rates and temperatures of the various extraction, filtrate makeup, and white liquor makeup flows.

Cooking uniformity: distribution of chemical and temperature

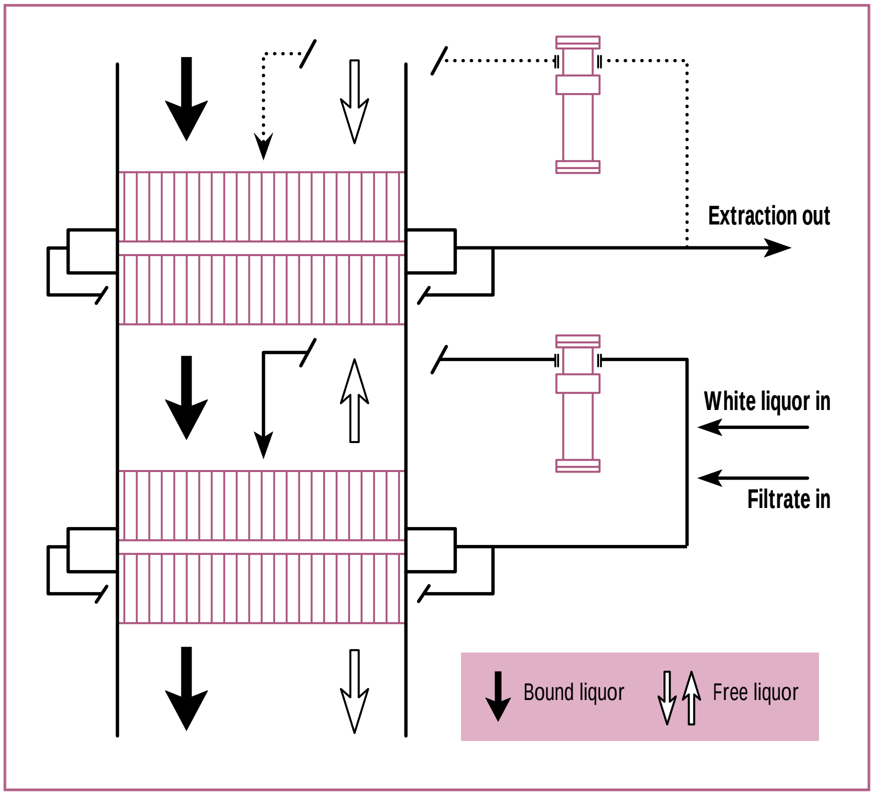
As with conventional cooking, it is important to ensure uniform distribution of cooking chemical and temperature. It is also necessary to ensure that the cooking chemical is never fully depleted at any location in the digester.

The use of an extraction, makeup, and dilution sequence can improve distribution of cooking chemical and temperature in two ways. First, the liquor turnover ratio at the heating circulation is increased. Secondly (for cases where extraction of spent impregnation liquor is followed by a downstream makeup and dilution), the cooking chemical and temperature are countercurrently contacted with the downflowing chip column.

The liquor turnover ratio is defined as the flow rate of circulated liquor per unit flow rate of total column liquor flow. It is the ratio of liquor which passes through the heater to total system liquor at a given location. The column liquor flow, or total system liquor, will vary from zone to zone in the digester.

For systems with a post impregnation extraction, makeup, and dilution sequence, the column liquor flow above the first set of extraction screens is decreased by decreasing white liquor charge to the feed. Liquor is then extracted from the system prior to heating, resulting in a further decrease of column liquor flow. The net effect is a large increase in the liquor turnover ratio at the heating circulation(s), and so radial temperature gradients will decrease significantly.

As a general rule, counterflowing distribution of temperature and chemical is more uniform than radial circulation. Upflowing liquor between circulation screens therefore will help distribute heat and white liquor to this zone.



3. Extraction followed by makeup and dilution in a split upflow/downflow heating circulation. Schematic shows two screen sections in the digester each with external heating circulation and central pipe discharge. Use of the first heating circulation is optional (denoted by dashed line).

1. *Mill "A" (British Columbia, Canada). Two vessel hydraulic digester built for EMCC cooking of northern softwood. Producing ECF bleached market kraft pulp. Lo-Solids pulping began October 1993. 10 to 15% increase in strength. White liquor application decreased by 1% on wood (EA as Na_2O). Extraction capacity increased by 20-30%.*

2. *Mill "B" (Alabama, USA). Single vessel hydraulic built for EMCC cooking of southern hardwood (integrated mill). Lo-Solids pulping began November 1993. Extraction capacity increased by 35 to 50%. Improved brownstock washing. Improved final (bleached) pulp viscosity.*

3. *Mill "C" (British Columbia, Canada). Two vessel hydraulic digester built for MCC cooking of northern softwood. Producing market kraft pulp (mixed bleached grades). Lo-Solids pulping began April 1994. 5% to 10% increase in strength, 25 to 30% increase in extraction capacity. Target kappa decreased 5 kappa units with no increase in white liquor application. Improved brownstock washing.*

4. *Mill "D" (Alberta, Canada). Two vessel hydraulic digester built for MCC cooking for northern softwood. Producing ECF bleached market kraft pulp. Lo-Solids pulping began April 1994. 5% to 7% increase in strength, 25 to 30% increase in extraction capacity. Improved brownstock washing.*

5. *Mill "E" (Alabama, USA). Two vessel hydraulic digester built for EMCC cooking of southern pine. Producing ECF bleached market kraft pulp. Lo-Solids pulping began July 1994. White liquor charge decreased by 0.5% on wood. 15% increase in extraction capacity, improved washing. No effect on pulp strength observed.*

6. *Mill "F" (Pennsylvania, USA). Single vessel hydraulic built for EMCC cooking of mixed hardwood (integrated mill). Lo-Solids pulping began September 1994. Extraction capacity increased by >30%. Improved brownstock washing. Improved final (bleached) pulp viscosity.*

7. *Mill "B" (Alabama, USA). Single vessel hydraulic cold-blow digester (i.e., no Hi-Heat wash zone, fully concurrent). Lo-Solids pulping began January 1995. Cooking temperature decreased by °C with no change in white liquor application or target kappa. Tear strength increased by >15%, folding strength increased by >30%, bleached viscosity increased by >16%. Full bleach sequence equivalent chlorine decreased by >20%.*

8. *Mill "H" (British Columbia, Canada). Lo-Solids pulping began April 1995. No results compiled as of May 1995.*

9. *Mill "I" (Mississippi, USA). Lo-Solids pulping began May 1995. No results compiled as of May 1995.*

10. *Mill "J" (Louisiana, USA). Lo-Solids pulping began May 1995. No results compiled as of May 1995.*

I. Reference list for Lo-Solids pulping as of May 1995

Survey of mill scale experiences

At time of writing, 10 digesters have been retrofitted and are operating with the new pulping process. As many as 15 additional retrofits are scheduled to come on-line by the end of 1996. Several others are anticipated shortly thereafter.

Table I is a summary of experiences with retrofits as of May 1995.

Examples of different process layouts: The K1 and K2 digesters at Gulf States.

The Gulf States, Demopolis mill (Mill B in Table I) is using the new process on both of its fiber lines. The first of the two digesters to be converted was K2: a recently commissioned single vessel hydraulic built for EMCC pulping of hardwood. K2 was originally equipped with provisions for 4 hours of countercurrent cooking in the vessel bottom. This digester has a total of five sets of screens and four heating circulations.

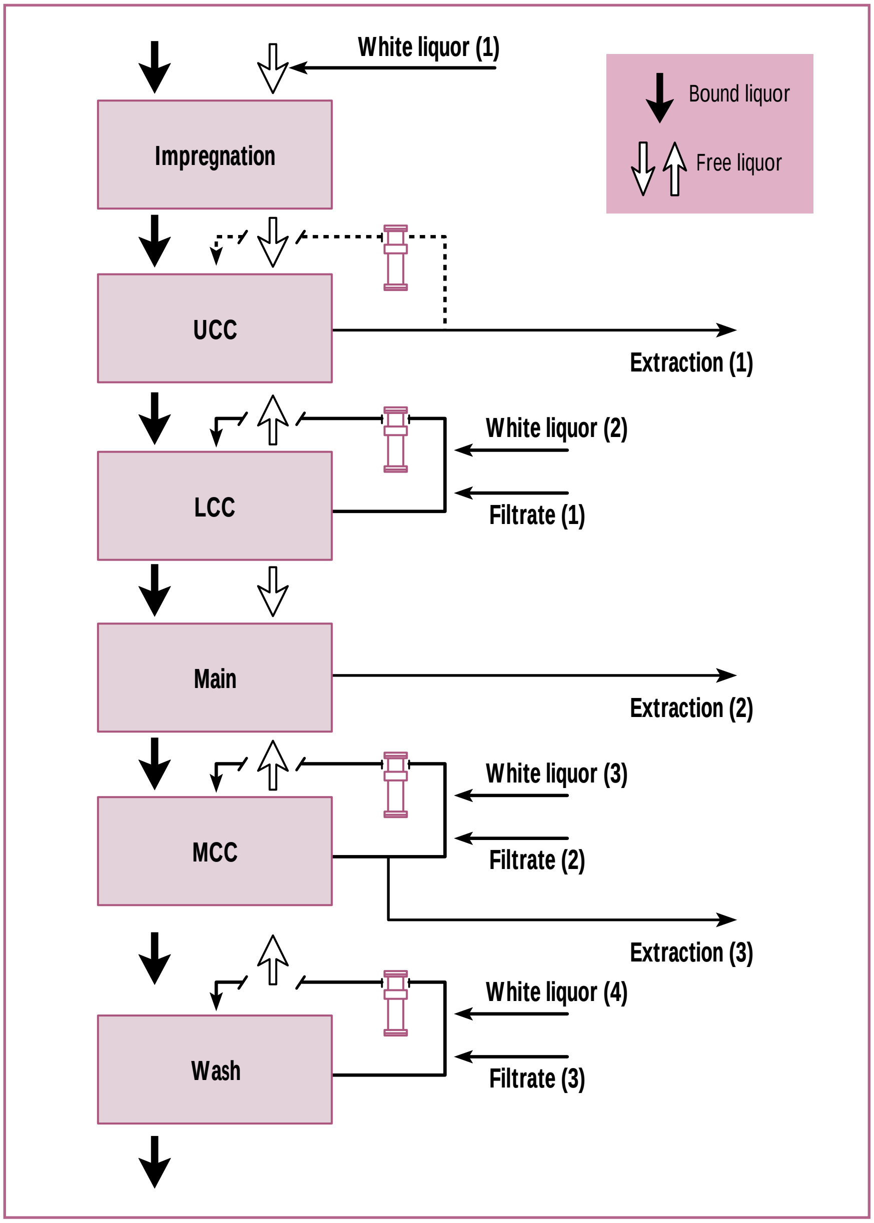
The new layout used for K2 is described in Fig. 4. For this layout:

- There are four white liquor addition points, three filtrate addition points, and three extractions in total.
- The concurrent impregnation zone is followed by extraction of spent impregnation liquor at the upper cook circulation (UCC) screens.
- The UCC heating circulation was shut down since it was rendered unnecessary by the conversion.
- Free liquor moves countercurrently upward in the zone between the UCC and the lower cook circulation (LCC).
- Makeup white liquor and filtrate are added and heated downstream of the first extraction, at the LCC.
- There is an upflow/downflow split of the combined makeup flows at the LCC.

- Beneath the LCC there is a concurrent cook zone followed by the second extraction.
- Beneath the second extraction there are two countercurrent cooking zones (the modified cook zone and wash cook zone), with the modified cook circulation (MCC) screens in between.
- A simultaneous extraction, makeup, and dilution is performed in the counter- current MCC heating circulation.

The older of the two digesters, K1, was one of the first continuous digesters sold in North America. It now swings between Southern pine and Southern hardwood. This unit was commissioned in 1958; before the advent of Hi-Heat™ washing. As such, there are no provisions for counterflow in the vessel bottom. The digester consists of an impregnation zone, two heating circulations (the UCC and LCC), a concurrent cook zone, and a set of extraction screens near the vessel bottom. Washer filtrate is added immediately below the extraction screens in order to dilute and cool the blown stock. This type of system is referred to as a cold blow digester. It is not possible to retrofit either MCC or EMCC cooking to such a system since there is no countercurrent zone in the vessel.

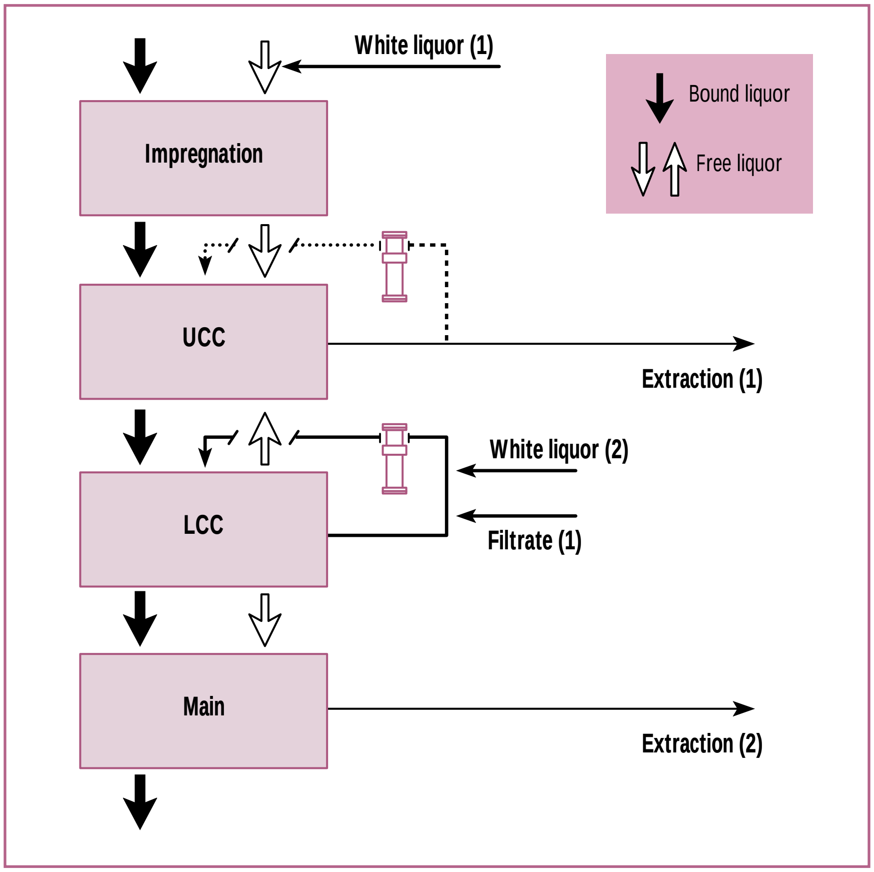
Based on their successful experiences with K2, the mill decided to apply the principle of extraction, makeup, and dilution on K1. Due to the remarkable differences in original shell configurations, the process layouts obviously differ between the two digesters. Figure 5 describes the new process layout for K1. The UCC and LCC screens were used for post-impregnation extraction followed by downstream makeup and dilution. There is an upflow/downflow split of free liquor at the LCC screens. The rest of the system beneath the LCC screens is operated as per the previous cold blow configuration.



4. Layout for Lo-Solids pulping on the Gulf States K2 digester. Blocks represent impregnation or cook zones within the vessel. UCC, LCC and MCC denote upper cooking circulation, lower cooking circulation and modified cooking circulation, respectively.

Effects on concentration profiles of dissolved wood solids

The use of multiple extraction, makeup, and dilution sequences results in significant reductions in the concentration of dissolved wood solids within the bulk phase of delignification. This is demonstrated in Fig. 6, which shows data from the Gulf States K2 digester. Compared are the measured dissolved lignin profiles before and after the conversion. In this case, the concentration of dissolved wood material is inferred from the concentration of dissolved lignin, or UV lignin. Dissolved lignin concentrations were determined by UV spectrophotome-



5. Layout for Lo-Solids pulping on the Gulf States K2 digester. Blocks represent impregnation or cook zones within the vessel. UCC and LCC denote upper cooking circulation and lower cooking circulation, respectively.

try. Values are plotted for liquor samples collected at various locations in the digester. The last datum of each curve represents the liquor squeezed from a 10% consistency blowline sample.

The data in Fig. 6 show that implementation of the new process resulted in improved digester washing. Overall, the conversion resulted in anywhere from a 10 to 30% decrease in concentration of dissolved wood solids within the bulk and final phases of delignification. Decreases in concentration were most evident in the wash–cooking zone.

For the K1 digester at Gulf States, the total dissolved solids in washer filtrate decreased from 14 to 8%. Similar effects, but of varying magnitude, have been observed at the other mills described in Table I. In several cases dissolved wood solids were measured indirectly by determining the chemical oxygen demand (COD) of digester liquor samples. Both the UV lignin and COD measurements were found to correlate well with measurements of total dissolved organics. The shape and magnitude of resultant profiles for dissolved wood solids will depend on the process layout and on the cooking conditions used.

Effect on pulp quality

A stepwise increase in the physical strength of final bleached pulp has been observed in all but one of the softwood mills which converted from EMCC to Lo-Solids pulping (refer to Table I). An increase of approximately 10% was observed in both the (2 x burst + tear) and the tear x tensile strength factors for Mill A. As of May 1996, this mill has been operating with the new process for over 30 months and the stepwise improvement in strength has been confirmed by comparison of long-term data. The viscosity of fully bleached pulp also increased (by 3–5 cP).

Physical strength, and tear strength in particular, increased in the other softwood mills as well. For Mills C and D the observed increases were of the order of 5–10%. Strength data from Mill E, however, did not show any significant changes. All three of these mills have arranged to publish their results independently.*(3-5)*

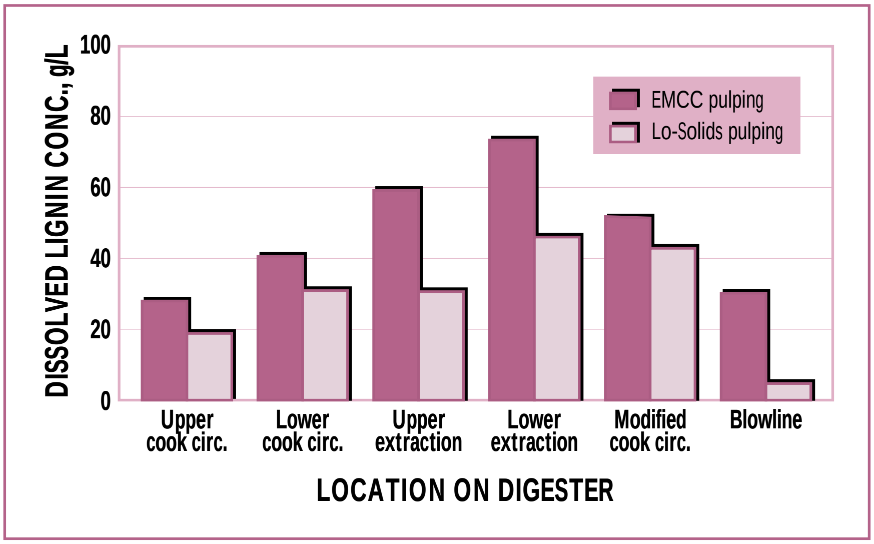
Certainly the most dramatic effect observed to date has been on the Gulf States K1 digester (Mill B in Table I). Tear and fold strength increased by approximately 15% and 30% respectively. The K1 digester was a unique retrofit in that it is the only system, to date, whose original configuration was a conventional, fully concurrent type cook. Similar results were observed at Mills H, I, and J.

The Gulf States K2 digester and the digester in Mill F both produce hardwood pulp for integrated paper production. Physical strength properties were not measured in either location as they were not of particular interest to the mills. In both cases it was noted, however, that the viscosity of bleached pulp increased after the transition to Lo-solids pulping (by between 5 and 10 cP). This is illustrated in Fig. 7 using data from Gulf States. Improved final pulp cleanliness has been reported for both of these hardwood mills.

Effect on extraction capacity and digester washing

The use of multiple extractions and filtrate additions naturally lends itself

KEYWORDS
Alkaline pulping, chemical pulping, chemical reactions, continuous process, cooking liquors, delignification, dissolved solids, kraft pulping, modified kraft process, solids content, solutes.



6. Effect of Lo-Solids pulping on lignin profiles for the Gulf States K2 digester. Concentrations of dissolved lignin as determined for liquor samples obtained at various locations on the digester. Data compares profiles for EMCC and Lo-Solids pulping. Blowline liquor obtained by de-watering a blowline pulp suspension sample.

to increasing overall digester extraction capacity. For systems which are limited in extraction capacity, (e.g., systems operating at rates which are significantly over design), this translates into the ability to use more washer filtrate in the digester without compromising column movement. This, in turn, results in improved digester washing. For conventional type systems, excessive extraction may result in extraction screen pluggage. In such cases, the multiple extractions in Lo-solids cooking can be used to diminish loading on the main extraction screens.

In all cases where the new pulping process has been implemented, a large almost instant increase in extraction capacity and improved washing was noted. At the same time, the tendency for screen blinding (as witnessed by high screen differential pressures) decreases. A dramatic example of this occurred on the Gulf States K2 digester.

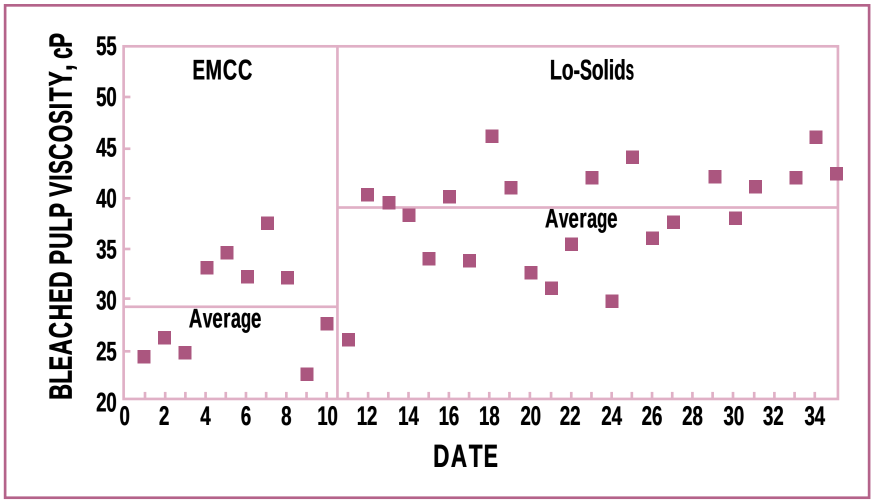
In Fig. 8, the digester's extraction factor (expressed as U.S. gal/min (USGPM) per a.d.metric ton/day) is shown for K2's transition to the new process. During the transition the number of extraction sites, as well as the extraction flows from each site, were increased sequentially. This resulted in a corresponding increase in the total, or overall extraction factor and in the amount of filtrate which could be used in the digester vessel. As can be seen, the overall extraction was increased by 45–50%. At the same time, the main extraction flow could be decreased by approximately 40%. This ultimately resulted in a 25–30% decrease in the washer filtrate's total dissolved solids concentration. Improvements in washing have been reported in all of the mills described in Table I. These improvements were particularly well documented at Mill D where a 20–30% decrease in blowline COD and a 20–25% decrease in brownstock defoamer usage were recorded. Decreases in COD carryover into the bleach plant were also noted.

Increased filtrate uptake has generally resulted in increased steam demand for the digester. Medium pressure steam requirements have increased anywhere from 5 to 25%, depending on process layout. At present, many of the mills described in Table I use filtrate taken downstream of their cold blow coolers as makeup. As a result, the net effect for these systems has been that a 10–25% increase in overall medium pressure steam requirement could be eliminated by by-passing the cold blow cooler or perhaps even preheating the makeup filtrate.

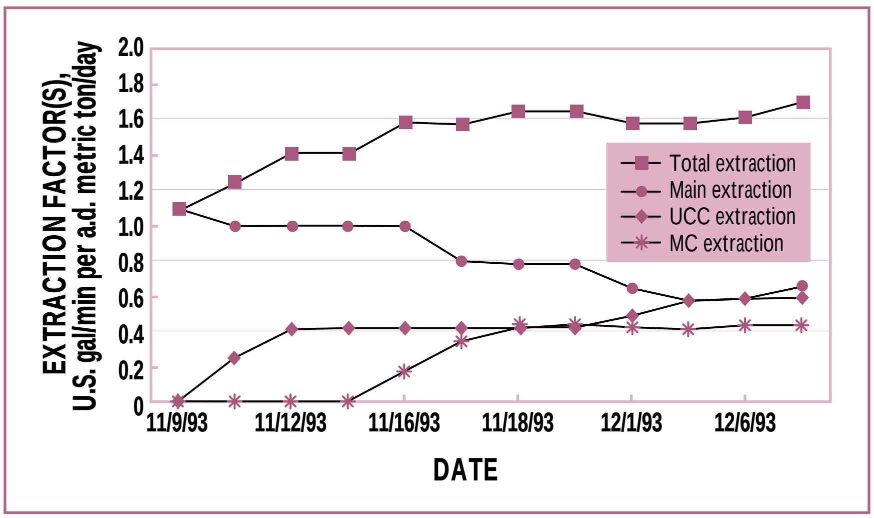
Effect on cook chemical and bleach chemical requirements

Results for white liquor application have been mixed. Decreases of 1% and 0.5% effective alkali (EA) on wood in white liquor application occurred at Mills A and E, respectively. In Mill C, the target kappa was decreased by 5 kappa units with no increase in white liquor application. For the Gulf States K1 digester, cooking temperature was decreased by 7°F with no change in kappa number or white liquor application. Mills B (Gulf States K2), D and F, however, have not reported decreases in white liquor application. At time of writing, results from Mills H, I, and J had not been compiled but they will be reported once available.

According to the laboratory results described earlier, *(1, 2)* it is estimated that the dissolved wood solids present in mill cooking liquors consume the equivalent of approximately 2% EA on wood in nonproductive, secondary reactions. Lo-Solids pulping can effect approximately 30% decreases in the amount and concentration of these materials



7. Effect of Lo-Solids pulping on bleached viscosity for the Gulf States K2 digester. TAPPI pulp viscosity from daily pulp machine composites during transition from EMCC to Lo-Solids pulping.



8. Effect of Lo-Solids pulping on total digester extraction flow for the Gulf States K2 digester. Data shows total extraction factor, and individual extraction factors for each extraction location during transition from EMCC to Lo-Solids pulping. UCC and MCC denote upper cooking circulation and modified cooking circulation.

within the vessel. It therefore would be reasonable to expect a 0.5% (on wood) decrease in consumption. Changes in white liquor application, however, will also depend on factors such as target cooking liquor residuals, total extraction flows, and cooking temperatures. Thus, decreasing liquor application will depend as much on optimization of the alkali profile as it will on minimization of the dissolved organics profile. For Mills B, D, and F, the total extraction flow was increased anywhere from 20 to 50% with only minor changes in extraction residual targets. Hence, while consumption decreased, application did not.

To date, we have not been able to quantitatively describe any effects on bleach chemical consumption for the retrofits of modified cooking systems. For the laboratory studies, minimizing the concentration of dissolved organics present during a modified cooking simulation resulted in a 10% decrease in bleach chemical consumption. If the full-scale process realizes 20% of that decrease in dissolved solids concentration, then a 3% decrease in bleach chemical consumption would be expected. Such an effect, although it may be real, is extremely difficult to measure in a mill environment.

On the other hand, very dramatic decreases in bleach chemical requirements occurred with the Gulf States K1 system: the full sequence equivalent chlorine charge decreased by over 20%. Once again, K1 was the first fully concurrent, conventional type system to be retrofitted with the new technology. A more pronounced effect on bleachability therefore was expected since the base case did not involve any modified cooking benefits. This result (coupled with the improvements in viscosity, tear strength, and fold strength) is extremely exciting in that it demonstrates the potential for obtaining modified cooking benefits in digester systems with little or no upflow.

CONCLUSIONS

Based on experiences at several mills, it is concluded that the use of multiple extractions followed by makeup and dilution has given a significant decrease in the concentration of dissolved solids throughout the bulk phase of delignification. As a result, pulp tear strength had been improved by as much as 5–15% for softwoods and pulp viscosity has been increased for hardwoods. Decreases in either cook chemical or temperature, and decreases in bleach chemical requirements have also been cited. For systems which were limited in extraction capacity, the use of multiple extractions and multiple filtrate additions has resulted in increased overall extraction and improved washing. Lo-Solids pulping has allowed continuous digesters with little or no upflow to obtain modified cooking benefits. Most systems can be retrofitted with only minor modifications and no risk to production capacity. TJ

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