Rapid displacement heating (RDH)-pulping system

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ABSTRACT

In the rapid displacement heating process (RDH), Hot spent cooking liquors are displaced from the digestors at the end of the cook by the use of washer filtrate. The pulp is thus washed and cooled below the flash point. The hot displaced liquors are stored inaccumulators and recycled to subsequent cooks to preheat chips and white liquors The washed/cooked pulp is blown from the digester to the blow tank using compressed air.

Compared to conventional cooking, RDH pulping has shown that digester steam consumption can be reduced by 60 percent. The pulp properties are improved. Cooking liquor displacement in the digester has contributed to low washing losses. The gaseous sulfur emissions from the blow tank are reduced by 90%.

This paper deals with the above Technology Development and its advantages.

Introduction :

Rapid Displacement Heating or RDH is a new low energy batch cooking process developed by Beloit Corporation.

Traditionally, there have been two principle methods for producing kraft pulp, batch and continuous digesters. Batch digesters have several inherent advantages over continuous cooking methods. For example, they are less sensitive to chip quality, generally have higher availability, and are able to produce different grades of pulp in the same cooking plant. Continuous digesters on the other hand, consume less steam than batch digesters. With the rising energy costs of the past years, much of the new pulp and paper industry cooking capacity has been based upon continuous digesters. RDH was developed as a method to combine the inherent advantages of batch cooking along with the energy efficiencies previously on available with continuous digesters.

The commercial implementation of RDH has resulted in steam savings that have exceeded original predictions. At the same time, a number of side benefits have been discovered which may prove to be far more valuable than simply conserving steam. These include stronger pulp, less alkali consumption, reduced load on evaporators and lower black liquor viscosities.

Commercial Installations :

There are presently seven commercial RDH installations in operation. The first was built at the Owens Illinois Mill at Valdosta, Georgia. This system reached full production in the spring of 1986. The cooking plant produces 870 ADMT/D of pulp for linerboard in ten digesters. RDH was installed as a retrofit.

After startup the mill experienced a dramatic reduction in digester area steam consumption (75–85%) : as well as, improved washing, increased production and reduced TRS emissions.

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The second installation was built at Joutseno Pulp Oy in Joutseno, Finland. The 950 ADMT/D bleached market pulp mill reached full production in the summer of 1986. The project included four new digesters of 200 cu.m. each which replaced two old continuous digesters. Seven existing 140 cu.m. digesters were retrofitted for a total of 11 digesters on RDH. Nominal capacity was reached with only nine digesters due to the shorter RDH cooking cycle. Steam savings averaged about 60% over conventional Scandinavian batch cooking methods. The mill experienced a 10% improvement in pulp strength properties for both bleached and unbleached pulps.

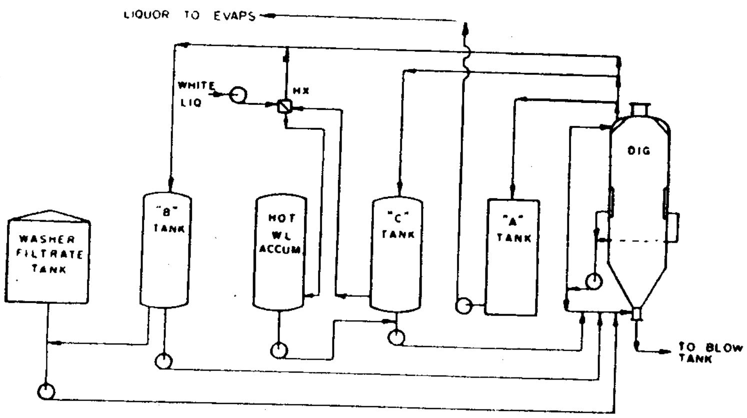


Figure-1b Stage 1 RDH System

Principles of Operation :

The principle equipment for RDH is shown in figure 1 a. and 1 b. In addition to the batch digesters, the principle components of RDH are :

— Digester displacement screens
— Hot black liquor accumulator
— Warm black liquor accumulator (s)
— Hot white liquor accumulator
— White/black liquor heat exchangers

One set of accumulators and heat exchangers can generally service any number of digesters.

RDH Cooking differs somewhat from conventional cooking.

First, digesters are filled with chips, using either liquor or steam packing to improve compaction density (i e., 6% improvement with liquor, 25% improvement with steam).

Next, digesters are filled with warm liquor. Air is displaced from the digesters and discharge valves are closed. The digesters are pressurized by warm liquor pumps to about 5.5 bar. The chips are thus pre-impregnated with weak liquor and the digester is hydraulically filled.

Hot white and hot black liquor are pumped into the digester displacing the warm liquor to the warm liquor accumulator or "A" tank. Soap is separated in the "A" tank and excess weak liquor is pumped to the evaporators. Digesters are thus brought to about 160°C before any steam is added.

On a continuous basis, hot black liquor from the "C" tank is passed through an indirect heater and used to heat incoming white liquor which is stored in an accumulator for the next cook.

Digesters are brought to temperature by direct steaming and "H" factor is accumulated. Once the desired "H" factor is achieved, washer filterate is pumped through the digesters displacing hot liquor to the accumulators. Approximately 70% of the hot liquor displaced remains at the cooking temperature. Hottest liquors are displaced to the "C" tank, cooler liquors are displaced to the "B" and "A" tanks. The digester is cooled to within a degree or two of the washer filtrate temperature. The full dilution factor added to the washers is thus passed through the digesters.

At this point, the cook has ended and the digesters can be blown at any convenient time. Pulp can be stored in the digesters without any further cooking reaction occurring.

The digesters are blown with compressed air. Original trials used steam, however, it was discovered that large quantities of steam were required to blow the cooled digester. This had a net negative impact on the energy efficiency of the system, but more important it was discovered that blowing the digester with steam resulted in a TRS containment problem similar to that of conventional batch cooking. In other words, a blow heat recovery system would be required to condense flash steam so that noncodnensibles could be contained.

Impact On Evaporators :

RDH can have a significantly favourable impact on multiple effect evaporator loading when compared to other cooking alternatives This is most easily seen in table 1 comparing the water balance to the evaporators for a conventional system versus RDH.

As indicated, the reduction in steam condensate and washed dilution factor with RDH cooking more than compensates for the lack of blow and relief steam associated with the process. Total potential reduction in evaporator load is approximately 17.5%.

Actual results at the Valdosta mill have indicated a steam reduction to the evaporators of about 10%. As the existing washers are considerably overloaded the washer dilution factor has not been reduced as much as might be expected with a properly sized washing line.

Impact On Liquor Cycle :

To date, alkali consumption Joutseno has been reduced from 18% on O.D. Wood to 17.5% on O.D. Wood. Control of the system has not been optimized. Earlier RDH trials indicated a potential reduction in alkali consumption of 10% when compared to conventional cooking methods.

TABLE—1

Water Balance to Evaporators Conventional vs. RDH (Liner Board)

	Conventional Batch T/ADMT	RDH Cooking T/ADMT
Flows in ;		
Wood (1.61 T solids)	1.61	1.61
White liquor (0 39 T solids)	2.06	2.06
Steam	1.38	0.30
Washer dilution factor	3.00	2.00
Subtotal	8.05	5.97
Flows out :		
Blow steam	0 90	0.00
Relief s'eam	0.10	0 05
Water recovery (1.07 T solids at 65%)	0.58	0 58
Su' total	1.58	0 63
Net evaporation requirement	6.47	5.34
Reduced evaporator load	–	17.5%

A reduction in alkali consumption in the degesters produces proportional reductions in inorganic load to the recovery boiler as well as a proportional reduction in the lime reburning requirements of the kiln T.is could result in improved recovery boiler efficiencies. It will certainly result in less fuel consumption in the kiln.

The main reason for this reduction alkali consumption appears to be less pulp degradation during the cook. It is during peeling reactions in conventional cooking that much alkali consumption and pulp degradation occur. These reactions do not appear to be as prevalent with RDH cooking.

Black Liquor Properties :

Recent work by sioderhjelm indicates that holding weak black liquor at high temperature and pressure for saveral hours (as inherently occurs in the RDH accumulators reduces the resulting viscosity of strong black liquor Figure 2 indicates the relative viscosities of strong black liquor resulting from the weak liquors entering and leaving the hot black liquor accumulator. It appears that strong black liquor solids concentration can be increased by about 3% and maintain the same viscosity.

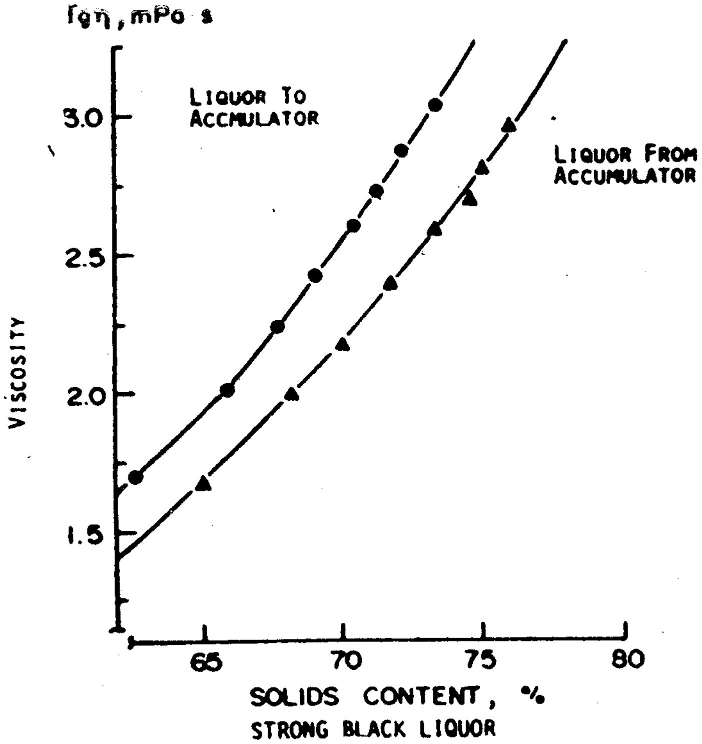
These findings imply some interesting possibilities, not the least of which is an increase in the solids concentration of black liquor fired to the recovery boiler. This could result in significantly improved recovery boiler efficiencies and increased effective recovery boiler capacity.

Digester Production :

RDH is more complex than conventional bath cooking, and therefore, raises questions about the pulp production per unit digester.

As seen in the Valdosta linerboard cooking schedules (Figure 3, even though RDH involves more steps than conventional, the accelerated time to temperature more than compensates for the extra steps.

This impact is even more pronounced at Joutseno where the cooking cycle has been reduced by 12.5% (from 240 minutes for conventional cooks to 210 minutes for RDH cover to cover).



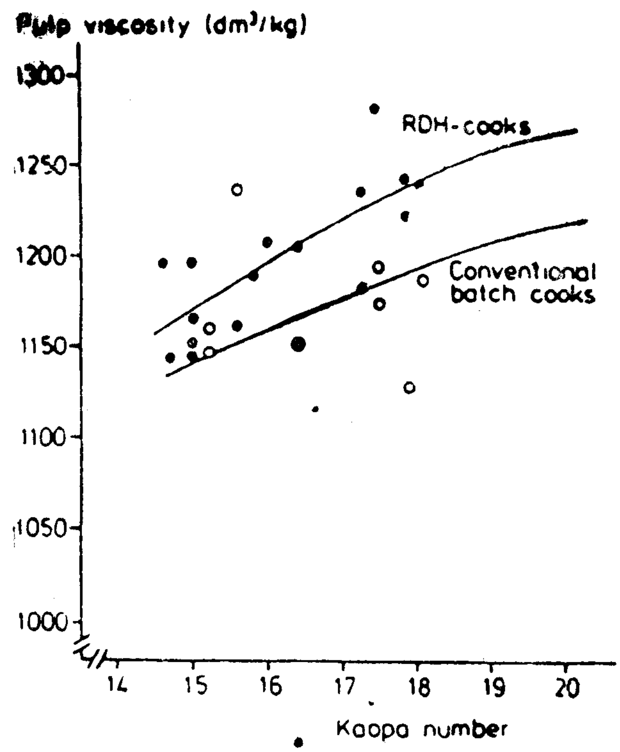


FIGURE 4

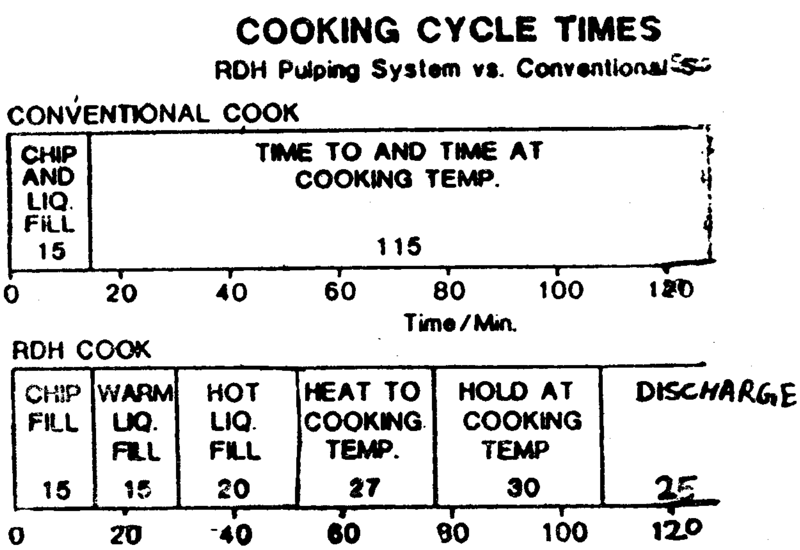


Figure 3 Cooking Cycle Times RDH Pulping System

VS.

CONVENTIONAL SYSTEM

Pulp Quality :

RDH incorporates a number of features that should result in improved pulp quality. For example,

- Preimpregnation with weak liquor containing relatively high sulfidity,
- Rapid rise to temperature
- High liquor to wood ratios
- Cold blow

Improvements were first seen in Scandinavian trials on hardwood as indicated in Figure 4 where RDH viscosities averages about 10% higher than those from conventional batch cooks.

These early indications of improved pulp quality have proven themselves on a commercial scale basis. Figure 5, compares the tear vs. tensile for unbleached conventional and RDH pulps at Jouteseno. As indicated the RDH pulps are significantly stronger than the conventional counterparts. Even more interesting is figure 6 which indicates that the strength improvements of the unbleached pulps carry through the bleach plant. B'eached pulp strength is now approximately 10% higher than it was when the mill was operating on conventional Scandinavian batch and continuous cooking modes.

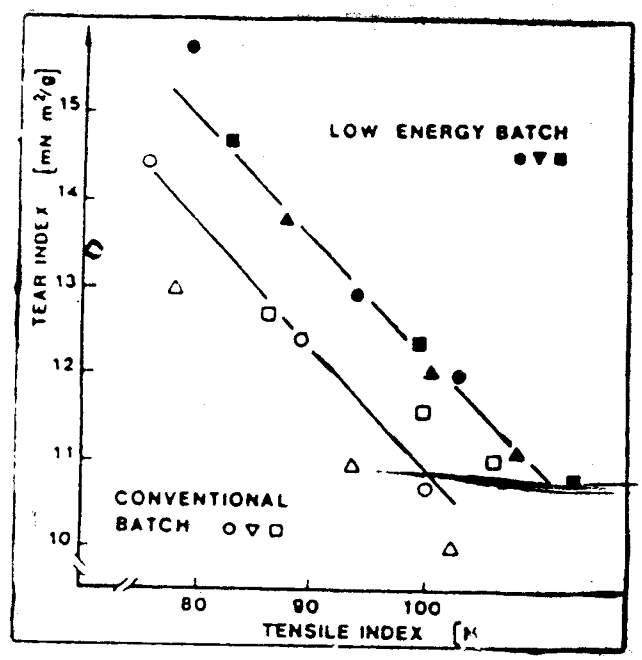


Figure 5.

Tear vs. Tensile for Unbleached Conventional and RDH Pulps at Joutseno

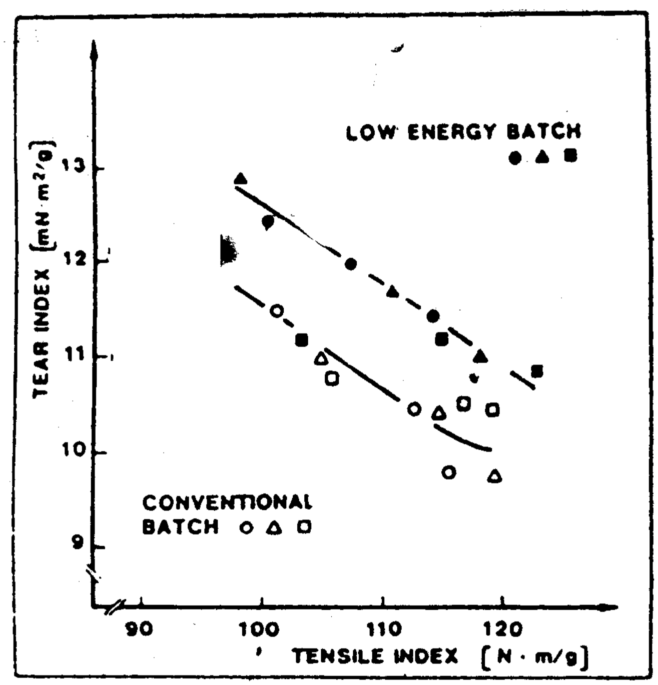


Figure 6.

Tear vs. Tensile for Bleached Conventional and RDH Pulps at Joutseno

Conclusions :

RDH can be installed with a number of heat recovery stages inorder to optimize digester steam consumption and by-product hot water generation.

RDH can result in significantly reduced loads to multiple effect evaporators.

Viscosities of strong black liquors resulting from the RDH process are significantly reduced compared to conventional liquors.

RDH cooking results in reduced consumption of alkali.

RDH cooking results in improved pulp quality compared to conventional methods.

Operation Cycle of the RDH Cooking System

Figure-1a

Time to/Time at Temperature

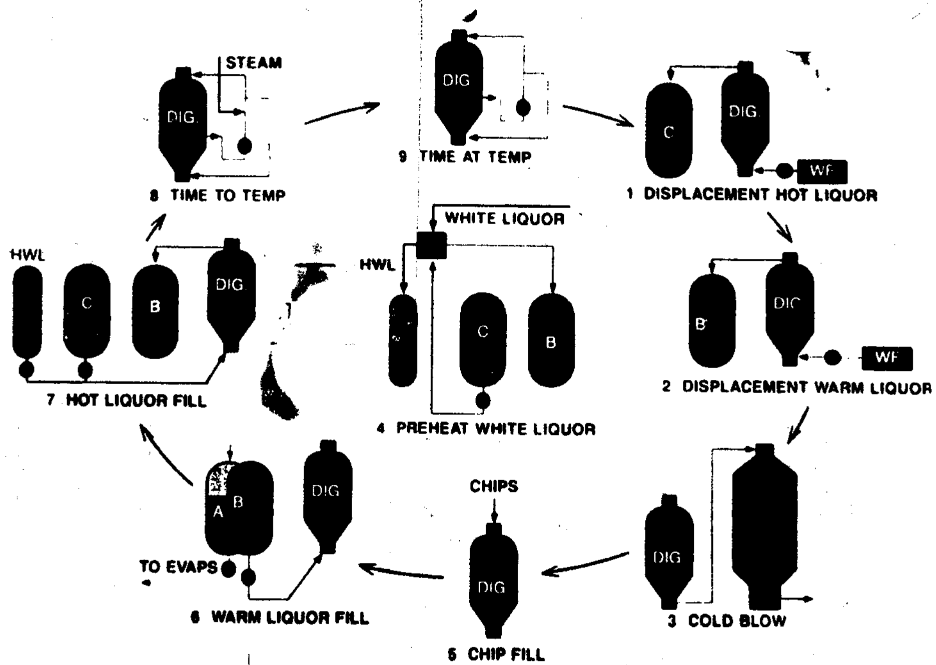
Extended Bulk Delignification
High Residual Alkali Concentration
No Lignin Condensation
Able to Cook to Low Lignin Levels

Displacement

Cooking Reactions Are Quenched
Digester Is Cooled
Empty Anytime
Contents Are Washed

Hot Fill

Rapid Heating
High Initial Sulfidity - 50%
Distributes White Liquor
Remove Hemicellulose



Cold Blow

Low Pressure Drop - 30 psig
No Mechanical Fiber Damage
No Flashing
Very Simple Odor Containment

Warm Fill

Preimpregnates Chips
Warm Liquor Sulfidity - 100%
Neutralizes and Removes Wood Acids
Accumulates Sulfur in Lignin
Remove Hemicellulose

Chip Fill

Steam Packing Gives 15-25% Compaction
Minimizes Channelling
Good Uniformity
Air Removed from Digester