"RDH-EB" Energy Saving And Environmentally Friendly Technology

RANGAN S.G.

ABSTRACT:-- Energy is currency. Once missed Savings are lost for ever. To achieve quantum Jumps in Energy Savings, Indian Pulp & Paper Industry should seriously consider going in for new equipment, Technologies and Processes that are energy efficient.

This Paper describes two latest Technologies that are revolutionising the World Pulp & Paper Industry by saving enormous amounts of Energy and being Environmentally friendly too.

Process details of Beloit's Rapid Displacement Heating Cooking System and Austria based IVA'S Cooking System called "Enerbatch" are described in detail. Their impact on Energy strength of Pulp and Environment are also discussed.

Combining the inherent strength of these two Technologies "RDH-EB Process for Kraft Pulping in Batch Digesters" is being made available to the whole world.

INTRODUCTION

Energy is like time-conservation once missed, savings are lost for ever. There should be an element of urgency for energy conservation in the country as a whole to stope the energy drain.

Short and long term strategies has to be developed in this field. Modernisation of old mills, use of energy efficient equipments and improvement of quality and productivity are the immediate steps in this direction. The answer to the increase in cost of production, scarcity of raw material and recession in the market is to accept new energy efficient Technologies in Pulp & Paper Industry.

Among these, most relevant to Indian Pulp & Paper Scenario are the RDH & ENERBATCH Pulping Systems - which are not only highly energy efficient but also environmentally friendly.

The Pulp Industry has accepted to modern batch cooking processes, which apply liquor impregnation and liquor displacement technologies. This has led to a pronounced comeback of batch systems in the past two years in USA and Europe.

As far back as the seventies liquor displacement in batch digesters has been applied in Russian Kraft Mill. In the eighties the displacement technology, combined with black liquor impregnation. was tested in mill scale and commercialized as RDH and later in addition, as Superbatch.

These two commercial systems use recirculated black liquor for preheating and impregnation of wood chips in the batch digester and an up-flow liquor displacement. This displacing liquors, such as the filtrate of brown stock washing for

Beloit Walmsley Ltd.
"AKSHAYA"
W-116 A, Annanagar, West Extn.
CHENNAI-600101 (T.N)

displacing the black liquor at the end of the cook, are pumped into the digester at the bottom and the displaced liquors are taken out at the top of the digester.

These process approaches resulted in a reduced energy consumption of up to 65% compared to conventional batch kraft pulping and brought batch cooking down to even lower level of energy consumption as continuous cooking. In addition, these kraft batch displacement technologies achieved a much more uniform delignification and highly improved pulp strength properties. An additional increase in strength properties was reached by pumping the pulp out of the digester instead of blowing it out based on a pressure difference.

"ENERBATCH" PULPING PROCESS

A finnish patented process modification, which applies **white liquor for impregnation instead of recirculated black liquor** as in the case of **RDH** and **SUPERBATCH** was further developed and adapted to meet industrial needs in the late eighties. The resulting process was called ENERBATCH.

ENERBATCH differs from RDH and SUPERBATCH in another important feature. The ENERBATCH technology applies down-flow liquor displacement instead of up-flow displacement.

Recently clear evidence was shown by Gullichsen et.al. that white liquor impregnation is superior to any other commonly used liquor impregnation. It is clearly better than black liquor impregnation. VAI/IVA Linz, Austria have shown in both pilot and industrial scales the superiority of downflow liquor displacement in combination with white liquor impregnation.

Both RDH and ENERBATCH Pulping Technologies save energy and are environmentally friendly.

RAPID DISPLACEMENT HEATING system developed to combine the inherent advantages of batch cooking with the energy efficiency previously only available with continuous digesters.

Commercial trials proved-Steam economy exceeded original predictions. A no. of side benefits were discovered which proved to be far more valuable.

WHY RDH

1. It saves Energy. Reduces steam demand by 60-70%.
2. It saves chemicals in Cooking, Washing and Bleaching operations.
3. It produces pulp which has 15-20% Higher Tear Tansile strength. Hence Better Machine Runnability is assured due to excellent quality of pulp.
4. Technology is Environmentally Friendly
   a. Less TRS emmissions.
   b. No-emmission of Mercaptain or Malodorous gases.
   c. Drastic reduction in TOCL, COX, BOD & COLOUR.
5. Although pulp of lower kappa is produced in case of Hard woods Kappa Nos. (10-13), strength is higher than that of conventional cooks.
6. RDH has Higher Brightness ceiling in bleaching operations.
7. One stage of in digester washing helps in minimising alkali losses.
8. RDH Pulping results in Lower Viscosity of black liquor going to SRP. Firing of black liquor can be at 75-80% solids.

RDH – HOW DOES IT DIFFER FROM CONVENTIONAL BATCH COOKS?

1. Air removal is ensured before pulping starts.
2. Digester is always full-liquor-wood ratio is very high at 1:5:2.
3. Extensive closed circuit recycling of energy and black liquor.
4. Pulp is quenched and pumped and not blown.
5. No steam released from blow tank and hence no maladourous emmissions.

6. Most black liquor removed from digester-very little can reach washer.

7. Displacement phase continued till washer dilution factor has passed.

PROCESS IN DETAIL

During the cooking process, the energy required to bring the organic mass to reaction temperature is generated by uniform displacement of hot spent liquor of previous cook through the wood chips. The uniform transfer of energy is achieved by monitoring liquid velocities to approach a plug flow condition. The RDH energy saving principle of recycling energy can be seen in Fig. No-1. Energy from the previous batch cook is stored in accumulators to be used in the next batch cook.

The RDH Process is a commercially proven technology with more than 12 installations (see table NO.2).

TABLE-1.

RDH COOKING OPERATIONS

Chip Fill

Warm Fill

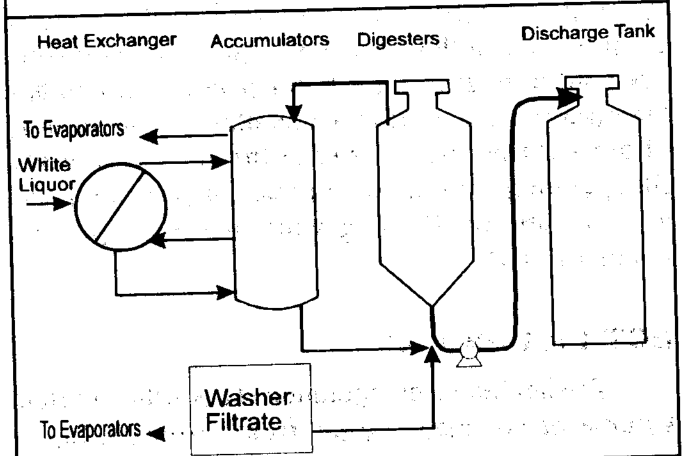
Hot Fill

TTT/TAT

Cool Displacement

Discharge

FIGURE-1: **RDH PRINCIPLES**



PROCESS DESCRIPTION

A typical flow diagram is presented in figure No.2. The operating steps are given in Table NO.1. Operation cycle of the BELOIT RDH Cooking System is shown in FIG NO.3.

TABLE-2.

RDH COOKING PROCESS REFERENCE LIST

Start-up	Customer	Digesters	Pulp
1985	Joutseno Joutseno Finland	4 New-200 cu.m. 7 Retrofit-140 cu.m.	Bleachable Grades Kappa Range 20-32 Softwood/Hardwood
1988	S.D. Warren Westbrook, Me. U.S.A.	4 New-200 cu.m.	Bleachable Grades Kappa Range 8-10 Hardwood
1990	Bowater Southern Calhoun, Tn. U.S.A.	8 New-200 cu.m.	Bleachable Grades Kappa Range 18-30 Softwood/Hardwood
1990	Fletcher Challenge Crofton, B.C. Canada	8 Retrofit-168 cu.m.	Bleachable Grades Kappa Range 26-30 Softwood
1990	Willamette Industries Bennettsville, S.C. U.S.A.	6 New-200 cu.m.	Bleachable Grades Kappa Range 16-24 Softwood/Hardwood
1991	Chung Hwa (A) Hualien Tiwan	5 Retrofit-120 cu.m.	Bleachable Grades Kappa Range 16-24 Tropical Hardwood
1994	Guangning Bamboo Guangdong Province P.R.C.	3 New-120 cu.m. Kappa Range 10-24	Bleachable Grades Bamboo
1994	Willamette Industries Bennettsville, S.C. U.S.A.	2 New-200 cu.m. Expansion	Bleachable Grades Kappa Range 16-24 Softwood/Hardwood
1995	Ruzomberok Slovakia	8 Retrofit-184 cu.m.	Bleachable Grades Kappa Range 10-30 Softwood/Hardwood
1995	Sodra Cell AB Morrum Mill Sweden	10 New-325 cu.m.	Bleachable Grades Kappa Range 9-12 Softwood/Hardwood

FIGURE-2 : RDH COOKING SYSTEM

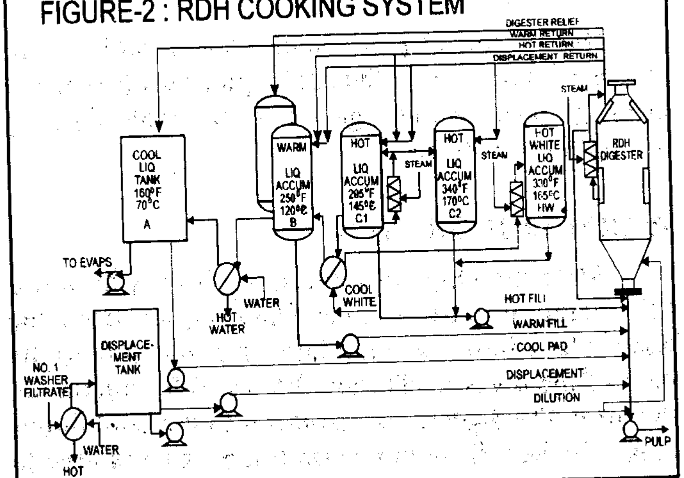
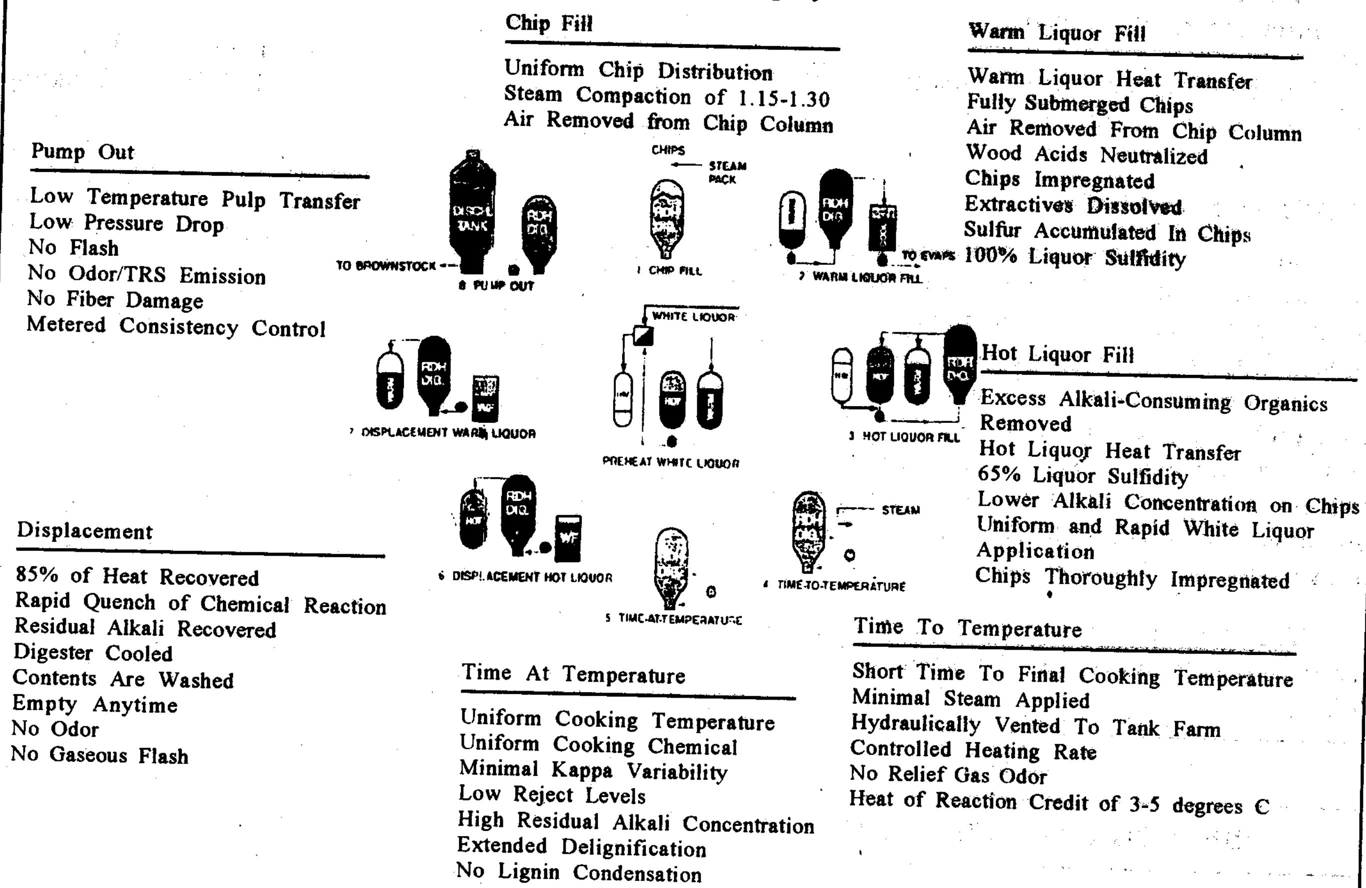


FIGURE-3: Operation Cycle of the Beloit RDH Cooking System



CHIP FILL

The RDH Process starts with the chip fill operation in a conventional manner. It can be a gravity fill or steam packing, depending on density of chips.

COOL PAD

During the chip fill operation, a cool pad of cool black liquor from the cool liquor tank is pumped in to the base of the digester to eliminate flashing during the warm fill.

WARM LIQUOR FILL

After the chip fill operation, the warm liquor fill operation starts. Warms black liquor from the warm black liquor accumulator is pumped in to the base of the digester. During the warm fill operation, the air in the digester is displaced to the cool liquor tank. The heat from the warm liquor is transfered to the chips as warm liquor flows through the chip column. At the same time, sulphides from the high sulfidity black liquor is being picked up by the chips. this mechanism enhances the selectivity of the RDH Chemistry. In order to transfer as much heat and chemicals are possible and to get air out as efficiently as possible, a volume of warm liquor exceeding the full liquor volume of the digester is used. When the present volume is reached, the pressure control valve at the top closes and pumping continues until a pressure of 6.5 bar psig is reached and then warm fill operation is completed. The purpose of pressurizing the digester at the end of the warm fill operation is to improve liquor impregnation and also to prevent flashing when the hot liquor fill operation starts.

HOT LIQUOR FILL

The hot liquor fill operation starts with a present volume of hot black liquor from the black liquor accumulator being pumped into the bottom of the digester, thus pushing the warm liquor in the digester out through the top of the digester. The displaced warm liquor goes back to the warm liquor accumulator. The over - pressure in the digester is maintained from now on by means of a pressure control valve in the out let line.

HOT WHITE AND BLACK LIQUOR FILL

When the target for initial black liquor is reached, the calculated volume of hot white liquor is added in combination with a suitable amount of hot black liquor. The control system is set up to handle this without an extra pump for white liquor. The total volume of hot black and hot white liquor being pumped to the digester will exceed the full liquor volume. At the end of the operation, the temperature of liquor leaving the digester will be high. At this point, the returning liquor will be switched to the hot black liquor accumulator. The digester temperature after the hot fill operation is typically 160°C.

CIRCULATION STARTS NOW!

At termination of the hot fill operation, the circulation of liquors begins, which indicates the start of the time to temperature operation. Initial circulation serves the purpose of elimination of gradients in temperature and chemical concentrations. After a present time, the computer will read the temperature and calculate the needed amount of steam based on target RDH cooking algorithms.

The digester pressure is controlled through this phase by a pressure control valve in a relief line (with blow back control) going from the relief screen in the digester top to the warm black liquor accumulator. The warm black liquor accumulator is vented to the NCG System on a continuous basis.

H-FACTOR - THE TARGET

The H-Factor accumulation begins when white liquor addition starts. When the H-Factor target is reached, the cooking is completed and the displacement operation begins.

DISPLACEMENT

The start of the displacement operation will terminate the cooking cycle. Washer filtrate is introduced to the digester bottom under pressure and thus displaces the hot spent liquor out of the digester top through a screen. The hot spent liquor is collected in hot black liquor accumulators. As the interface of washer filtrate travels up through the digester, an interface zone is formed. This zone grows as the interface moves towards the digester top. In that interface zone there is a temperature gradient from cooking temperature to a little bit over filtrate temperature. There is also a gradient in concentration between original liquor concentration and a little bit over filtrate concentration. The upper portion of that zone has temperature and concentration similar to original liquor. When the free liquor volume and the upper portion of the interface zone is displaced, the temperature starts dropping. A volume corresponding to full liquor volume in digester and dilution factor on the washers is used for the displacement. The displacement with filtrate cools the digester down to below 100°C and this displacement gives washing of the pulp that corresponds to one stage of vacuum washing.

DISCHARGE OF PUMPING

After displacement, the digester is emptied by pumping out to a discharge tank, which is proven technology for RDH. Pump-out has the advantages of easier handling of gas emissions from the discharge tank and elimination of air entrainment in the stock. Consistency in pump out is approximately 5.5%.

The tank farm provides intermediate storage for the various RDH liquors (see figure No. 2). These tanks are the "A" cool liquor tank, the "B" warm black liquor accumulators, the "C" hot black liquor accumulators, the hot white liquor accumulator and the displacement tank.

The Tank farm is where continuous liquor transfers take place, while maintaining adequate volumes in each tank during the cycles in each digester.

IMPACT ON BLEACH PLANT

RDH can have a mojor impact on the bleach plant. The RDH cooks can be extended to very low kappa numbers (low lignin content).

Hard wood pulp at 18-20 kappa with conventional kraft cooking can be 8-10 kappa with RDH cooking.

IMPACT ON PULP QUALITY

There has been a significant improvement in pulp quality at all the commercially operating systems.

IMPACT ON LIQUOR CYCLE

The amount of white liquor demand is equivalent to conventional kraft process for obtaining lower kappa numbers. The same amount of white liquor removes more lignin, therefore the organic to inorganic fraction in the black liquor is increased.

The viscosity of black liquor from the RDH process is lower than conventional kraft process. This feature increases the solid concentration of the black liquor that is burned in the recovery boiler.

IMPACT ON ENERGY

The RDH process is more energy efficient system than conventional batch cooking and continuous cooking systems. 55-75% of steam used in Batch digesters can be saved.

IMPACT ON ENVIRONMENT

RDH is environmentally friendly because it reduces the demand of bleaching chemical by reducing the kappa number in to the bleach plant. Also TRS Emissions are negligible as the pulp is pumped from digester and is not blown.

IMPACT ON YIELD

Because of selective delignification, cellulose is least affected as in conventional cooks. Bleached pulp yield will be same or slightly more as that of conventional cooked and bleached pulp yield.

IMPACT ON STRENGTH OF PULP

RDH produces pulp having the strongest tear - tensile strength.

RDH CHEMISTRY

1. In conventional batch digesters initially E.A. is high and sulfidity low.

   In RDH initially E.A. is very low and sulfidity is very high.

2. Hemi celluloses and wood acids that would normally consume so much alkali during initial delignification phases - removed from scene of action.

3. Sulfidity is very high all through the cook. Lignin is thoroughly sulfidated ready to disintegrate when reched by alkali and temperature.

Sulfonation - Key to selective delignification

Studies at STFI has shown that a "deficiency of sulfide" seems to appear in the beginning of conventional kraft cook. This has been observed in different ways by both liquor analysis and by wood residue analysis.

In the RDH Cooking process, black liquor containing hydrosulfide ions are displaced through the chips prior to cooking which counteracts the "deficiency sulfide". This may be the main explanation of why the RDH process gives better selectivity towards delignification than conventional batch kraft cooking.

4. Chips are heated quickly through the harmful range of temperatures which cause cellulose degradation but very little delignification, Chemicals are brought to react with wood components at the right time and temperature.

5. It is during peeling reactions in conventional pulping high alkali consumption and cellulose degradation occur. These reactions do not appear to be prevalent.

6. The high molecular fractions influence black liquor viscosity is undoubtedly caused by the continuous deploymerisation of dissolved black liquor lignins by higher than conventional residual alkali.

7. In bleach plant shrinkage is hardly 2-4%.

8. Carbo Hydrates react at lower temps with NaOH. But as only very small amounts of NaOH is present, no degradation takes place.

ENERBATCH COOKING TECHNOLOGY

Enerbatch is an energy saving batch technology for kraft displacement cooking. It applies pressurized white liquor impregnation and down-flow liquor displacement. This displacement is carried out from the top of the digester downwards to the circulation screen.

The main process characteristics are shown on Figure No.-4.

For extended delignification, the ENERBATCH concept includes the followings steps: Figure No.-5.

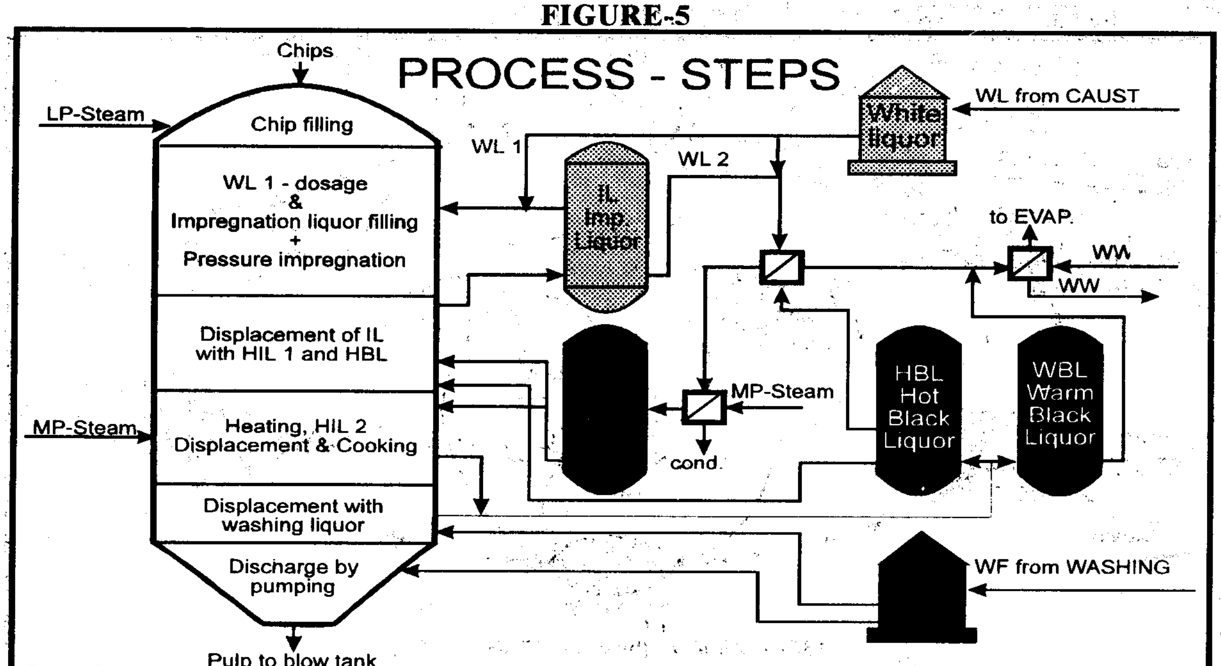
1. Chip filling with steam packing
2. White liquor and impregnation liquor filling - Lower Temp.

FIGURE-4:

PROCESS CHARACTERISTICS

- White - Liquor - Impregnation
  brings the alkali with pressure deep into the chips (less alkali input, fewer rejects)
- Displacement Technology
  uses the heat energy from the cooking liquor of the last batches to heat up the actual batch rapidly and minimises the primary energy consumption
- Alkali Splitting for Extended Delignification
  results in an even alkaliprofile
- Cold - Blow
  means pumping out the digester after displacement by cold washing filtrate (first washing stage is in the digester, environmental friendly, fiber protecting)

FIGURE-5



3. Pressure impregnation

4. Hot impregnation liquor and hot black liquor charge (hot displacement)

5. Circulation - Heating

6. Cooking including split alkali addition

7. Cold displacement by washing filtrate

8. Discharge by pumping

For high kappa pulp, alkali splitting can be simplified or omitted.

SPECIAL CHARACTERISTICS OF ENERBATCH

PRESSURIZED WHITE LIQUOR IMPREGNATION

The "ENERBATCH" Cooking cycle is shown in Figure No.-6. Pre heating and air removal is done by steam packing and impregnation liquor filling.

The pressure impregnation with fresh white liquor and recirculated impregnation liquor at about 8 bar and 90°C, results in fast and uniform distribution of alkali and sulfide throughout the digester right into the core of the chips. The velocity and uniformity of this impregnation has been demonstrated for several wood species in IVA'S pilot plant (VABIO).

Because of this "cold" pressure impregnation, additives such as polysulfide can be effectively applied to the chips. Also anthraquinone can already be added at this stage. All results reported in this paper have been achieved without any such additives.

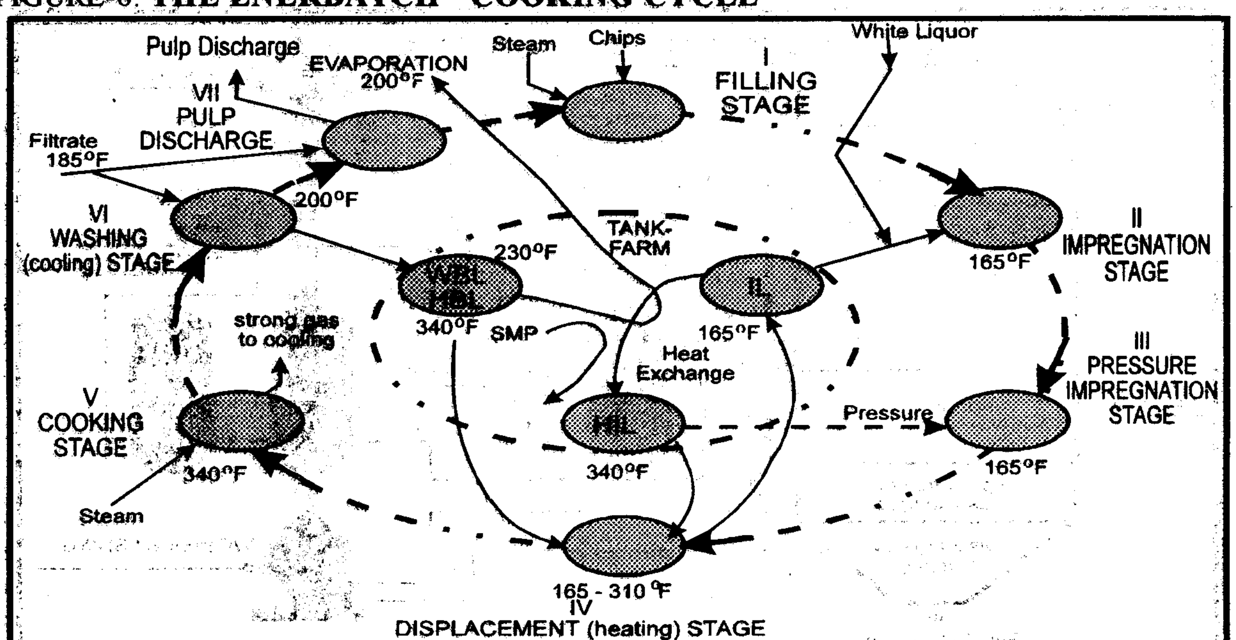
DOWN FLOW DISPLACEMENT

The down-flow displacement technology of the ENERBATCH Process means that all liquor displacement steps are performed from the top of the digester to the bottom which leads to an optimum displacement profile. No channelling arises. This results in uniform temperature and liquor/chemical flow conditions throughout the digester during every cooking phase. This increases, in addition to the pressure impregnation uniformity, quality and yield of ENERBATCH pulps.

HOT IMPREGNATION LIQUOR

The ENERBATCH technology has a "wildcard" to bring the digester, after "cold" impregnation, rapidly to cooking temperature and to adjust to some extent also the dosage of Chemicals: The hot

FIGURE-6: THE ENERBATCH® COOKING CYCLE



impregnation liquor (HIL). HIL is the same liquor used for "cold" impregnation liquor (IL) heated to a temperature near or even somewhat above cooking temperature. HIL is applied together with HBL to displace IL. Quantity, temperature and alkali concentration of HIL can be freely varied. Quantities of HIL + HBL for displacing IL exceeding the volume of the digester were tested in pilot plant. This process is called overdisplacement. It was noticed that without changing the total chemical consumption time for heating up was reduced and no pronounced negative temperature peak was in this precooking phase. This implies shorter cooking time and higher production for a given digester volume. In addition there are positive effects on yield and strength properties.

RDH - VS - EB EVALUATION

Wood species tested in Pilot Plant :

European mixed Hardwood,

European Softwood.

Evaluation for Both Processes:

a) Yield - VS - Kappa number

b) Brown stock strength, Viscosity, Tear - Tensile Bleachability

c) Bleached Pulp strength, Viscosity, Tear - Tensile

CONCLUSION

BELOIT - IMPCO Division is currently analyzing the data to come-up with optimized process and equipment configuration by combining the strengths of two processes. Combined Process may be called "RDH - EB".

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(5) Personal discussions with "ENERBATCH" Experts in LINZ, AUSTRIA.

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(7) Visits to ENERBATCH Pilot Plant and NETTINGS DORFER - PAPIER FABRIK AG MILL in LINZ, AUSTRIA.