Kraft Pulping
Past, Current & Future

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Continuous Cooking
The continuous digester
Past – Current - Future

Content

• The development of the continuous digester
• The first generation of digesters, ca 1950 – 1980
  - Conventional cooking in single and two vessel digesters
• Second generation, modified cooking, ca 1980 – 2000
  - MCC, EMCC, ITC, BLI, etc.
• Current, ca 2000 - ????
  - Compact cooking
  - ImpBin™
• Modification of old digesters
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Those who did it!!!
The inventors of the continuous digester ~ 1950, Kamyr AB, Karlstad Sweden
First pilot plant 1944 – Kalix, Sweden
Version 1
First pilot plant 1944 – Kalix, Sweden
Version 2
First working High Pressure Feeder
Second generation High Pressure Feeder
Modern High Pressure Feeder

- Chips and liquor
- Chip chute
- Rotor
- Prefilling slot
- Chip and liquor to top circulation
- Chip chute circulation
- Liquor in
- Lubrication liquor in
- Liquor
Conventional chip feeding system

Diagram showing the system components:
- Air lock
- Chip Bin
- Chip Meter
- LP Feeder
- Steaming Vessel
- Inline Drainer
- Level Tank
- Sand Trap
- Chute circ. pump
- White liquor

Connections:
- Steam, air and turpentine to treatment/recovery
- Relief Strainer
- Chip Chute
- HP Feeder
- Top circulation
- Make Up Liquor pump
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Digester types

- Single vessel steam/liquor
- Single vessel hydraulic
- Two vessel steam liquor
- Two vessel hydraulic
## First reference list

<table>
<thead>
<tr>
<th>Customer</th>
<th>Country</th>
<th>Capacity ADMT/24 h</th>
<th>Process</th>
<th>Raw material</th>
<th>Year of start-up</th>
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<td>1955</td>
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<td>Esparto</td>
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</table>
Typical continuous digester 1950 – 1980

Typical operating figures:

- Cross sectional load 25 – 28 adm/m² (2.3 – 2.6 bdst/ft²)
- Cooking temperature soft wood 165 °C / 329 F
- Cooking temperature hard wood 160 °C / 320 F
- Top pressure 7 bar(g) / (100 psig) steam phase type
- Top pressure 10 bar(g) / (145 psig) hydraulic type
- Residual alkali 6 – 8 g/l as EA₉NaOH
- Wash factor 2 m³/admt (after 1960)
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Continuous Cooking Development

1980

The four rules of Kraft pulping STFI/KTH

1990

The modified rules of Kraft pulping KTH/Metso

2000

The rules of carbohydrate retention Metso

MCC

ITC

BLI

COMPACT COOKING™

COMPACT COOKING™-G2
The four rules – slightly modified

1. The alkali concentration should be as even as possible
2. The temperature should be low throughout the cook to minimise carbohydrate degradation
3. The concentration of HS- should be as high as possible
4. The concentration of dissolved lignin has no negative effect as long as the alkali concentration is sufficiently high
Two vessel S/L digester with MCC

Softwood example

- Impregnation: 125 °C / 257 F
- Con current cooking: 158 °C / 316 F
- Counter current cooking: 162 °C / 324 F
- Counter current washing: 135 °C / 275 F
After MCC came ITC

ITC™ cooking uses the washing zone for final cooking.

The cooking time is prolonged and cooking temperature is decreased.

The result is a more selective cook.
Two vessel S/L digester with MCC and ITC
Softwood example

- Impregnation: 125 °C / 257 F
- Con current cooking zone 1: 156 °C / 313 F
- Counter current cooking zone 1: 156 °C / 313 F
- Counter current cooking zone 2: 156 °C / 313 F
The development from 1960 – 1990

Summary

Conventional cooking

MCC

ITC™

~ 1962

~ 1985

~ 1990
By 1990 the complexity had reached it’s peak!
Single vessel hydraulic digester with MCC & ITC
It was necessary to do something!!!
Reduce the number of screens in the digester!
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Continuous cooking

Pushing the limits

Digester capacity

© Metso
Continuous Cooking Development

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ITC

COMPACT COOKING™

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Impregnation
Relative rates for diffusion and reaction

The best impregnation is obtained by a low temperature and a long impregnation time.

Cooking chemicals penetrate the chip without being consumed.
CompactCooking™ G2
Alkali profiling
A short retention time – increased temperature

The H-factor contribution is increasing exponentially with an increased temperature. The increase is drastic when the temperature exceeds 165 °C.
HS- concentration profiles

Recirculate black liquor
Avoid dilution with wash liquor

A high HS- concentration brings:
- Increased delignification rate
- Decreased amount of residual phase lignin
- Increased cooking selectivity
CompactCookingTM™

R & D had shown:

- Alkali & HS⁻ profiling is crucial
- A low temperature is important for carbohydrate retention

The big question was: How do we do this?
Which way to go?
A two vessel system was chosen
CompactCooking™

It was obvious that a two vessel digester must be used!

But how do we get the chips into the digester?

Customers had started to ask for production levels unheard of before!!

2000 t/d → 3000 t/d → 4000 t/d → ????
A conventional feeding line
Chips

- ~1/3 wood
- ~1/3 air
- ~1/3 water
Heating of chips

Source: Based on experiment by Karin Wilson UHB Skoghall.
Feeding, steaming & impregnating in one vessel??

Chip buffer & steaming

Impregnation

=}

Chip buffer & steaming

Impregnation
ImpBin™

- Impregnation liquor
  - Max chip level
  - Min chip level
- Chip buffer zone
- Cold layer
- Steaming zone
- Impregnation zone
- IMPBIN™ extraction
- Dilution
ImpBin™

Upper part
CompactCooking™ G2 with ImpBin™

Typical retention times

- Chip buffer zone: ~10 min
- Impregnation zone: 60 min
- 1st Cooking zone: 100 min
- 2nd Cooking zone: ~100 min
- Washing zone: 40 min
CompactCooking™

Reduced reject content due to improved impregnation

An improved impregnation reduces the reject content.
CompactCooking™

Reduced cooking temperature (SW)

CompactCooking G2

Optimizes the process conditions

Low cooking temperature
CompactCooking™ G2 – cooking development

Reduced operating and capital costs

Comparison based on a HW 2500-3000 ADMT/24h cooking system.

<table>
<thead>
<tr>
<th></th>
<th>MCC/ITC™</th>
<th>COMPACT COOKING™ G1</th>
<th>COMPACT COOKING™ G2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rejects (%)</td>
<td>~1-2</td>
<td>~0,5-1</td>
<td>&lt;0,5</td>
</tr>
<tr>
<td>Power Consumption (kWh/admt)</td>
<td>~35</td>
<td>~30</td>
<td>~20</td>
</tr>
<tr>
<td>Steam Consumption (kg/admt)</td>
<td>~500</td>
<td>~450</td>
<td>~400</td>
</tr>
<tr>
<td>No. of Rotating Machines</td>
<td>25-28</td>
<td>20-22</td>
<td>11-13</td>
</tr>
</tbody>
</table>

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Replacement of a conventional feeding line with an ImpBin™
Conversion of an old hydraulic digester to CompactCooking™ G2

The conventional feeding line is gone and so are the flash tanks. A pressure diffuser has been added to improve the washing.
Continuous Cooking
Process development

- 1957: CC + Cold Blow
- 1962: CC + Hi-Heat
- 1993: BLI™ + MCC + ITCT™ (Hi-Heat)
- 1997: Compact Cooking™
- 1997: CC + MCC + ITCT™ (Hi-Heat)
- 2001: CC + MCC + ITCT™ (Hi-Heat)
Nueva Aldea CompactCooking™ G2, Chile
Thank you!

Questions?