Rethinking the art of refining
Improve the efficiency and quality of refining

The nature of refining
Mechanical treatments are applied to fibers to improve:
• sheet forming
• flock formation
• sheet strength
• etc.
Therefore the fibrous material is subjected to shear and compression in the gap between rotating and stationary refining elements (bars).

Refining Theory: The History

1887 Refining with cylindrical beaters (Hollander), F. Jagenberg:

\[ I = \frac{F}{A_{\text{avg}}} \]

The Jagenberg Bar Crossing Area was a function of the Jagenberg Length, which is THE CENTRAL FIGURE OF ANY CURRENT REFINING THEORY:

Jagenberg Length = Crossing Length Per Second:

\[ L_{\text{avg}} = \frac{AL_{\text{avg}}}{B} \]

Jagenberg Area = Average Momentary Bar Crossing Area

\[ A_{\text{avg}} = \frac{\sum L_{\text{avg}}}{B} \]

So after introducing a frictional coefficient converting Normal to Frictional Forces we get:

Refining Theory:
The History

1864 J.M.J van Stiphout: \[ I = \frac{[N\cdot m/s]}{[Pa\cdot s]} \] or \[ [N/s] \]
• Suggest to define the likelihood of a fiber to be in the refining gap.
• Refining pressure in the gap was a function of fiber mass in the gap and average bar contact length.
• Formulas were complicated, the approach was forced out by specific edge load theory

1966 W. Brecht, W.H. Siewert: Specific Edge Load theory → \[ I = [N] \] or \[ [W/s/m] \]
• Put the Edge Load theory by Wultsch and Flucher to the test on different refiner geometries with the following comparison identities:
  • Bar width = same, Bar angle = same, Plate material = same, etc.
  • With these boundary conditions they write a hypothesis about fiber quality development due to refining:

The fiber quality after refining is the same, if specific edge load (SEL) and net specific refining energy (SEC) are the same. \[ Q_{\text{fiber}} = Q_{\text{fiber}} (\text{SEL, SEC}) \]
The Nature of Refining

Based on the fiber quality changes affected by refining, some key questions need to be addressed to describe the refining action:

- How many stress cycles are imposed on an average fiber?
- What is the degree of compression for such a cycle?
- How much shear is applied in a stress cycle?
- How many fiber layers are present in the gap and therefore – what is the likelihood of fiber to bar interaction?

The Specific Edge Load Theory provides no answer to any of these fundamental questions.

Rethinking the art of refining

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The Magnus™ Simulation Model

What’s the difference of this theory to the theories proposed before? Historically refining intensity was calculated from an “outside” perspective (geometry and energy), but Magnus views the process quasi from an “inside” perspective:

- A “fiber treatment” consumes energy locally (compression, shear,...) and the sum of all those events determines the energy consumption
- Fiber Morphology, freeness, lignin content, flow and consistency are taken into consideration in addition to plate geometry and energy consumption (the fiber is allowed its voice)
- And most importantly for the purposes of Scaling Refining Action (Similarity Theory): All Parameters describing the Nature of Refining are DIMENSIONLESS NUMBERS

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What does Compression Index Mean?

The Meaning of Compression Index – Softwood Fibers

- Pure Brashing, CI = 1.0
- Pure Squeezing, CI = 2.7
- Pure Cutting, CI = 4.5
- Best Compromise, CI = 1.7

Rethinking the art of refining

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The Magnus™ Simulation Model

How do X and CI influence fiber quality?

More treatments are achieved by:
- Higher edge length plate
- Overhang plate
- More refiners in Series

More compression is achieved by:
- More refiner loading
The Magnus™ Simulation Model
How do X and CI influence fiber quality?

TENSILE
CSF

Rethinking the art of refining
Improve the efficiency and quality of refining - Magnus™

The constant angle
• To ensure consistently high quality in the processing of fiber material, any form of process variability should be minimized.
• Research shows that bar angle significantly influences refining results.
• Yet, the crossing angle of parallel bar plates varies significantly.

Innovation 1
Spiral bars

Bar Angle Optimization
Combining different bar angles on rotor and stator side when calculating the effect of crossing angle on the number of treatments at identical specific edge length yields the graphs to the right.

There is an optimal bar angle combination on rotor and stator, which all Lemaxx Spiral products adhere to.

Innovation 2
V-shaped groove – use of highly abrasion resistant alloys

Toughness of the bars by design.
• Refiner plates are expected to show high service life in order to minimize costs and set-up times.
• But refining action and occasional tramp materials demand high toughness alloys, which naturally have lower wear resistance.
• So how can we use highly abrasion resistant alloys as a plate material while also withstanding the high mechanical load on the bars?
**Innovation 2**

V-shaped groove – use of highly abrasion resistant alloys

Toughness of the bars by design.

- We strengthened the bars at the base on one side. Two bars together form a V-shaped groove.
- The grooves between them are deeper and thus compensate the hydraulic losses of the V-shaped grooves.
- The result: Homogenous fiber treatment and quality by high durability and long service.

Different materials for different applications:

- Low carbon stainless steel alloys for high toughness environments
- High carbon stainless steel alloys for above average impact resistance and maximum allowable HW-ratios

**Training Package:** LemaxX Signature Series

**Innovation 2**

V-shaped groove – use of highly abrasion resistant alloys

Toughness versus wear resistance

Toughness (Impact resistance)

- Demand: Lower intensity and more efficient plates while delivering higher hydraulic capacity
- Higher ratio between bar height and bar top width - Taller, thinner and lower draft angle
- Special attention to alloy selection by balancing wear resistance and design breakage resistance

Benefits high-toughness alloys:

- Maximum HW-ratios
- Best-in-class bar breakage
- Maximum bar edge integrity

Benefits high-lifetime alloys:

- Moderate to high HW-ratios
- Maximum wear resistance
- High corrosion resistance integrity
- Best-in-class toughness at high wear resistance level

**Innovation 3**

Strategically placed dams - LemaxX Signature Series

The overall hydraulic behavior.

- High process quality with ever more efficient use of energy is expected.
- How can refiner plate design contribute towards saving energy?
- Can we improve the pumping characteristics and overall hydraulic behavior of the refiner?
Innovation 3
Strategically placed dams - LemaxX Signature Series

New Patterns at a glance

- **What is our pattern numbering system?**
  - **How to know that a pattern is a Signature Series?**
    - It has strategically placed dams
    - 42TASS205 .. SS .. = Signature Series
    - 42TASS205R .. SS .. = Signature Series for Rotor Only

<table>
<thead>
<tr>
<th>Flow Type</th>
<th>Pattern 1</th>
<th>Pattern 2</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Flow</td>
<td>42JASS209/210</td>
<td>42JASS209/210</td>
<td>Regular SS pattern is run on rotor; stator is running the same design. SS indicates Signature Series.</td>
</tr>
<tr>
<td>Medium Flow</td>
<td>42JASS209R/210R</td>
<td>42JASS209/210</td>
<td>Regular SS pattern is run on the stator. R at the end of the pattern number; rotor only.</td>
</tr>
<tr>
<td>High Flow</td>
<td>42JASS208/210</td>
<td>42JASS209/210</td>
<td>Regular SS pattern is run on all patterns. What is running is regulated by the application.</td>
</tr>
</tbody>
</table>

Innovation 3
Strategically placed dams - LemaxX Signature Series

LemaxX Signature Series
Combining design benefits

- LemaxX 106 series
- LemaxX 200 series
- LemaxX Signature series

- Homogeneous fiber treatment and quality
- Homogeneous fiber treatment and quality
- Homogeneous fiber treatment and quality
- High durability long service life
- Reduced energy costs