Developments in use of MFC in packaging specialties.

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Per Svending, VP Marketing
We make composites of MFC and mineral

FiberLean® MFC, Microfibrillated Cellulose, is a composite produced by co-grinding cellulose fibers with minerals, such as GCC, PCC or kaolin, based on a proprietary patented process.

FiberLean facilities are installed within paper mills and use pulp and fillers which are already available on-site, minimising input and logistics costs.

When cellulose fibers and fillers are co-processed in aqueous suspension, minerals act as fine grinding media and reduce processing costs.

No pulp pre-treatment is required. FiberLean can be made using any chemical pulp and paper filling mineral in the market. MFC content can be varied.

The production process does not feature chemical additives and yields a stable ready-to-use composite.
Higher filler loading in uncoated woodfree papers through use of MFC-mineral composites

Full scale UWF results with 1 and 2% MFC addition

<table>
<thead>
<tr>
<th>Property</th>
<th>% change at +10% filler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk</td>
<td>- 1%</td>
</tr>
<tr>
<td>Tensile</td>
<td>- 3%</td>
</tr>
<tr>
<td>Opacity</td>
<td>+2% units</td>
</tr>
</tbody>
</table>

% change vs. % filler increase

Ref. 1% MFC 2% MFC
The most important effect of MFC for filler increase is the impact on initial wet web strength

Note: This is pilot trial results using 450 ml CSF, 30% Pine / 70% Euca furnish and GCC filler.
Improved base paper to make better coated papers through use of MFC-mineral composites

Full scale results with 1.5% MFC addition

Higher gloss and opacity as a result of better coating hold-out.
For today’s standard papers it is all about cost

As from the previous example:

- 7.5% pulp replaced by filler
- 1.5% pulp transformed to MFC

Today’s cost differential between pulp and filler is often €500 per dry ton or more.

Adding 7.5% more filler creates €37.50 per ton of paper in gross value.

To create net value the cost of transforming pulp to MFC must be below €2 500 per ton.
Folding boxboard is a superior stiffness board grade.

Publically available stiffness specifications

Basis weight for 13 Taber stiffness:
- FBB: 270
- SBB: 310 +15%
- WLC: 350 +30%
## Folding Boxboard can be made even better

<table>
<thead>
<tr>
<th>FBB</th>
<th>SBB</th>
<th>WLC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical pulp liners</td>
<td>All chemical pulp</td>
<td>Recycled white pulp liners</td>
</tr>
<tr>
<td>Mechanical mid ply</td>
<td></td>
<td>Recycled mid ply</td>
</tr>
</tbody>
</table>

- Highest bulk/stiffness
- Best looks/convertibility
- Lowest cost per ton

- Folding Boxboard mid ply bulk can be increased by reducing mechanical pulp refining energy.
- The limitation to this is set by the mid ply strength, typically the Z-directional strength.
- MFC can help overcome this limitation.
Strength from MFC can be successfully traded for better bulk/stiffness and higher productivity

Results from full scale trial

The "adjustment" made here is making the mid-ply pulp coarser, i.e. reducing the refining energy.

* MFC added as 50% composite with GCC, so 2% filler is also added.
Folding Boxboard application, full scale results

Filler increase and basis weight reduction in Top/Back

- 2.25% MFC in each
- +10% filler in each, 4 g/m² of top layer and 3 g/m² of bottom replaced by middle layer
- Conditions chosen to maintain stiffness
- Machine speed, filler retention and runnability maintained

Specification maintained at reduced cost

- Bending stiffness and brightness unchanged
- Significantly improved smoothness
White Top Liner application, full scale results

Filler increase and basis weight reduction
- 2.5% MFC in white layer
- +9% filler in the white layer
- 10 g/m² of top layer replaced by brown layer
- Conditions chosen to maintain brightness
- Machine speed, filler retention and runnability maintained

Specification maintained at reduced cost
- Minor changes in strength properties
- Large reduction in air permeability
- 40% increase in Scott Bond
- Potential for higher filler increase and brightness
Two approaches to using MFC-mineral composite to make white top liner

Much less bleached fiber needed to make printable surface

- **Reference**
  - Typical white top kraftliner of today
  - 1/3 bleached fibre
  - Poor printability

- **MFC-mineral as filler**
  - Composite filler
  - 1/4 bleached fibre
  - Better printability

- **MFC-mineral as coating**
  - Composite coating
  - 5% MFC
  - Best printability

- **Legend**
  - MFC
  - Mineral
  - Bleached pulp
  - Base liner
Wet-end coating on top of the wire section

- MFC-mineral composite applied as a low solids slurry on top of the still consolidating base layer.
- The composite has the ability to stay on the surface without penetrating into the base.
- The top layer is drained using existing foils and vacuum boxes.
- Pressing and drying as normal for the combined coating and base board.
- The top layer is strong and has good adhesion while offering coverage, low porosity, smoothness and excellent printability.
High growth print methods are challenging the substrates ability to manage large amounts of water

**Inkjet**
Water content of ink is about 90%
4x100% CMYK => ~ 16 g/m² water

**Flexography**
Water content of ink is about 50%
4x100% CMYK => ~ 4-8 g/m² water

**Offset**
Water from fountain solution only
4x100% CMYK => ~ 1 g/m² of water
Mercury porisometry measurements on conventionally and MFC-mineral wet-end coated White Top Liner

MFC-mineral coating yields larger pores and more pore volume

Samples 1-4 are composites of MFC and different minerals.
Print properties as a function of pore structure

Samples 1-4 are composites of MFC and different minerals.
MFC-mineral composite coating offers great printability for inkjet and flexo, ideal for printed white boxes

Images of print scanned from pilot made WT linerboard
Surprise, surprise. No smearing!

The MFC-mineral composite coating is good at accepting moisture from water based inkjet printing.

Our inkjet printing development partner is Screen GP IJC in Cambridge, UK
Our goal is attractive and well defined

The challenge is to make it work at high speed

- Being able to feed a highly viscous suspension through an applicator.
- Applying the coating without damaging the still unconsolidated sheet below.
- Create good formation to get the surface coverage needed.
- Rapid water removal using existing drainage elements.
- Ensure good runnability through press section.
How to make a composite gel structure like this work in a coating application?

10 000 Pa s viscosity @ 0,01 s⁻¹ shear rate for a composite at a total solids of 10%.

Dilution is obviously a possibility but will naturally result in more water to drain, through the base sheet.

Optimizing solids, viscosity and drainage is a key consideration for successful high speed operation of this coating method.
The MFC-mineral composites are shear-thinning
Alternative application principles evaluated

Speed vector of top layer «jet» at impact point
Speed vector of the fourdrinier wire / base layer

Slow pilot machine

Alternative approaches at high speed:
- curtain, contact mode
- curtain, pressurized
- inclined jet
- parallel jet drag
- parallel jet rush

FiberLean Technologies
Pilot trial application of 30 g/m² dry MFC-mineral composite at 500 m/min on top of 70 g/m² base

Several alternatives have been evaluated on high speed pilot machines.

Under the right conditions high-speed application works!
Couch and press solids are dependent on keeping application solids high

**Couch solids:**

<table>
<thead>
<tr>
<th>% solids of web</th>
<th>70 g/m² base paper only</th>
<th>30 g/m² @ 10% solids</th>
<th>30 g/m² @ 5% solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>19</td>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>

**Press solids:**

<table>
<thead>
<tr>
<th>% solids of web</th>
<th>70 g/m² base paper only</th>
<th>30 g/m² @ 10% solids</th>
<th>30 g/m² @ 5% solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>46</td>
<td>45</td>
<td>44</td>
<td></td>
</tr>
</tbody>
</table>
Wet-end coating as a pre-coat

For barrier coatings or for hold out of other costly coatings

- An unbleached longfiber kraft pulp makes a pretty open sheet.
- Application of 30 g/m² is sufficient to increase the Gurley number from about 10 sec to 250 sec.
- It is interesting to think of this as a pre-coat for specialty coated papers.

For paper machines with only one conventional coating step, in film press or similar, this could represent entirely new possibilities.
Making lighter paper with more filler without sacrificing tensile strength or opacity

If bulk and stiffness are not important there is an opportunity

<table>
<thead>
<tr>
<th>g/m²</th>
<th>Reference</th>
<th>2% MFC</th>
<th>4% MFC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MFC</td>
<td>Filler</td>
<td>Pulp</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>15 g/m² lighter</td>
<td>-24% weight</td>
<td></td>
</tr>
</tbody>
</table>

FiberLean® Technologies
Summary: Addition of MFC offers several possibilities

- Cost reduction through filler increase
- Improve coating hold-out
- Light weighting
- New product development