Breakthrough in Papermaking Resource Efficiency with Foam Forming

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BACKGROUND: VISION FOR PAPER AND BOARD (~2008)

- **Radical resource savings**
  - Raw materials: 20-40%
  - Energy: 50-60%
  - Water: 60-80%

- **Bio-based materials**
- Advanced nanomaterials

**Foam forming technology enables both**

- Potential technology for packaging, tissue, non-wovens, insulation, hygienic products, composites,…

- **Increased value through renewal**
  - New fiber-based products outside traditional value chains
FOAM FORMING - BASICS

- Fibers and other furnish components are mixed with foam instead of water.
- Foam consists of water, foaming agent and air. Typical air content 50-70%.
- Air bubbles prevent flocculation of fibers in the headbox.

**Froth**, 2-4 mm bubbles
'Fairy foam, dish washing'

**Foam**, 20-100 μm round bubbles
Dense foam
FOAM FORMING AT SUORA ENVIRONMENT
PILOT SCALE FOAM FORMING RESEARCH ENVIRONMENT – SUORA

- Technical specifications
  - Web width 300 mm
  - Design speed 2000 m/min
  - Sampling speed <1000 m/min
  - Several forming geometry options
  - Two foam generation options (tank mixing & tube generation)
  - Single nip press section
  - Off-line dryer
# Development from Lab to Pilot Scale

<table>
<thead>
<tr>
<th></th>
<th>Handsheet formers</th>
<th>Small-circulation device ‘KISU’</th>
<th>SUORA-research environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sample size</strong></td>
<td>A4 &amp; 500*500 mm. Laboratory pressing &amp; drying</td>
<td>Web width 120 mm. Laboratory pressing &amp; drying</td>
<td>Web width 250 mm. Reeled sample &amp; offline cylinder drying</td>
</tr>
<tr>
<td><strong>Web speed</strong></td>
<td>-</td>
<td>300 m/min (foam) 300 m/min (water)</td>
<td>~1000 m/min (foam) 2000 m/min (water)</td>
</tr>
<tr>
<td><strong>Amount of fibers</strong></td>
<td>&gt;Few grams</td>
<td>&gt; 5 kg</td>
<td>&gt; 300 kg</td>
</tr>
<tr>
<td><strong>Layered products</strong></td>
<td></td>
<td>3-layers (foam) Single layer (water)</td>
<td>Single layer (foam) 3 layers (water)</td>
</tr>
<tr>
<td><strong>Forming geometry</strong></td>
<td>1-sided dewatering</td>
<td>1-sided dewatering</td>
<td>Fourdrinier / hybrid / gap</td>
</tr>
</tbody>
</table>
MAIN BENEFITS OF FOAM FORMING
HIGH BULK

- new raw material combinations
- raw material savings
- usage of materials impossible in water or dry laid technologies
SUPERIOR FORMATION INDEPENDENT OF FIBER LENGTH

- 69%
- 49%
- 16%
+ 41%

Water
Foam

Birch 1

Optical formation [-]

Headbox consistency [%]

Water
Foam
STRENGTH AT LOW GRAMMAGES

- Pine pulp
- Bulk values at the same level

Tensile Index [Nm/g] vs Grammage [g/m²]
STRENGTH PROPERTIES AS GOOD AS FOR MILL REFERENCE

- Foam forming trials at VTT SUORA research environment
- Basis weight 40 g/m²
BULK INCREASED MORE THAN 50%
FOAM FORMING – ORIENTATION CONTROL

- Foam forming trials at VTT SUORA research environment
- Open jet geometry
- Jet speed 300 m/min
- Basis weight 70 g/m²
- SW kraft pulp

- Possibility to control MD/CD tensile ratio between 2.2 and 7.0 by changing J/W speed ratio
LIGHTWEIGHT STRUCTURES FROM NOVEL RAW MATERIAL COMBINATIONS

- Natural fibres
- Synthetic fibres
- Regenerated fibres
- Foam +
- Ultra lightweight materials
- Nanomaterials
- Functional chemicals
### MATERIALS FOR CONSTRUCTION, INSULATION, PACKAGING…

<table>
<thead>
<tr>
<th>Sample</th>
<th>Thickness (mm)</th>
<th>Grammage (g/m³)</th>
<th>Density (kg/m³)</th>
<th>Bulk (cm³/g)</th>
<th>Thermal conductivity (λ₁₀ W/(m·K))</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 CTMP</td>
<td>32.0</td>
<td>800</td>
<td>25</td>
<td>40</td>
<td>0.0403</td>
</tr>
<tr>
<td>100 Pine pulp</td>
<td>33.8</td>
<td>885</td>
<td>26</td>
<td>38</td>
<td>0.0354</td>
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<tr>
<td>80/20 CTMP/NFC</td>
<td>33.7</td>
<td>820</td>
<td>24</td>
<td>41</td>
<td>0.0357</td>
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<tr>
<td>80/20 CTMP/PCC</td>
<td>59.3</td>
<td>760</td>
<td>13</td>
<td>78</td>
<td>0.0362</td>
</tr>
<tr>
<td>50/50 CTMP/pine</td>
<td>38.7</td>
<td>845</td>
<td>22</td>
<td>46</td>
<td>0.0372</td>
</tr>
<tr>
<td>80/20 CTMP/PCC (1)</td>
<td>87.0</td>
<td>720</td>
<td>8.3</td>
<td>120</td>
<td>-</td>
</tr>
<tr>
<td>Styrofoam</td>
<td>25.3</td>
<td>530</td>
<td>21</td>
<td>48</td>
<td>0.033-0.038</td>
</tr>
</tbody>
</table>

The best thermal conductivities are comparable to mineral and stone wool insulation materials.
FOAM FORMED SOUND ABSORBANCE MATERIALS

- Challenges under 500 Hz
- Sound absorption 500 Hz:
  - 0.3 VTT’s foams
  - 0.1-0.6 commercial products
- Encouraging results; no structural optimization was done.
FIBER BASED MOULDABLE PACKAGES

VTT’s mouldable fibrous material has the potential to replace plastics in all deep drawn goods which have reasonably low dimensions e.g. 16 cm and 11 cm in length, and 1,75 cm in height.
WHY FOAM TECHNOLOGY?

- The only known technology, which can significantly improve the competitiveness of current products and enable the renewal of forest industry sector with new products (incl. SMEs)
  - Rebuilding of existing manufacturing lines with low investment costs
- There is existing infrastructure for wood based business, which still has a great influence on employment
- Foam forming is a technology already in commercial use (specific nonwovens). We will transfer it to new product areas.
- VTT is building an international foam technology platform
RESOURCE-EFFICIENT FORMING PROCESS

- Significant resource savings are expected for foam forming technology
  - The biggest advantage through fiber savings
  - Less drying energy due to decreased basis weight
  - Chemical costs are lower due to reduced basis weight and improved retention
- Clear improvement in resource-efficiency and benefits in adding value to fiber-based products.
VALUE FOR FUTURE

• Foam forming will lead to a new manufacturing platform for fiber based products as it
  • Requires significantly less raw materials, water and energy than conventional manufacturing
  • Improves many product properties
  • Enables exploitation of new raw material combinations from nanoparticles to long fibres
  • Offers a sustainable solution to manufacture a wide range of products such as paper, board, tissue, hygiene products, insulation materials, filters and other added value products from bio-based, long fibers
  • Offers possibilities for both large companies and SMEs to create novel value chains

• Fast product and process development by using VTT’s facilities from laboratory to pilot scale.
VTT creates business from technology