Tuning of mechanical properties of wet-laid nonwovens and paper through the use of tailor-made viscose fibres

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Kelheim – Fibres GmbH
Outline

• Kelheim-Fibres GmbH, the company

• Viscose fibres
  - The Viscose fibre toolbox

• Tuning of paper & nonwoven mechanical properties
  by incorporation of viscose fibres

• Summary
Kelheim Fibres – The world leading manufacturer of speciality viscose fibres

Head Office
Kelheim, Niederbayern
Capacity
~ 75.000 to/year
Staff
~ 500
Turnover
~ 150 Mio Euro

R&D Background of most historically leading viscose producers


1936
Süddeutsche Zellwolle AG, Kelheim, start-up of viscose fibre production (DANUFIL®)

1968
Acquisition of a majority shareholding by Hoechst AG

1994
Joint Venture Courtaulds European Fibres

1999
Acordis Kelheim GmbH

2004:
Kelheim Fibres GmbH
Take-over by EQUI- Fibres GmbH
Viscose Fibres – chemistry made by nature

Cellulose + NaOH + CS₂ → Cellulose Xanthogenate

Cellulose Xanthogenate + H₂SO₄ → Regenerated Cellulose

+ NaOH + CS₂

+ H₂SO₄ + CS₂ + Na₂SO₄
A Very Special Material: Cellulosic Fibres

Unrivalled properties
- physiologically neutral, skin-friendly
- hydrophilic, perfect moisture management
- excellent dispersability
- restricted growth of micro organisms
- chemical stability, does not melt
- chemical reactivity (printability, processability, versatility)
- easy modifiable
- hydrogen bonding capability
A Very Special Material: Cellulosic Fibres

Viscose fibre tool box
Fibre modifications for improved mechanical properties
Viscose Fibres modifications

**Cross sections**

- **hollow flat**
  - Bramante / Dante

- **flat 1:20**
  - Bellini

- **regular round**
  - Danufil®

- **flat 1:4**
  - Viloft®

- **trilobal**
  - Galaxy®
Viscose Fibres modifications

Fibre dimensions

Fibre length: 3 – 12mm short cut

Mean fibre diameter: 8 – 45µm (0,7 – 27dtex)
Viscose Fibres – fibre modifications

Functionalization

Incorporation of additives

Extra absorbency

Chemical modification:

- Coatings
- Anionic modification
- Cationic modification
- Ion exchange
Viscose Fibres – fibre modifications

Viscose fibre development tools
Wet-laid inclined wire pilot line
Tuning of mechanical properties of wet-laid nonwovens and paper through incorporation of viscose fibres
Tuning of paper properties – viscose cross section

Influence of cross section → Paper density

Density of paper sheets

- 100% Pulp
- Bellini
- Bramante
- Viloft®
- Galaxy®
- Danufil®

Density in % versus 100% pulp

Rapid-Köthen sheets 80g/m²; Pulp: Eucalyptus 16°SR; Viscose: all fibres 3,3dtex; 6mm
Influence of cross section → Paper & NW strength

Regular viscose will not form a 100% paper or NW without additional chemical or mechanical bonding
Influence of cross section → Paper strength

Flat & hollow flat Bellini and Bramante will give 100% viscose paper sheets without additional bonding
Tuning of paper properties – viscose cross section

Strength of sheets with viscose / pulp blends.

Tear strength of paper sheets

10% Viscose in blend

- 100% Pulp
- Bellini
- Bramante
- Viloft
- Galaxy
- Danufil

2% Viscose in blend

- 100% Pulp
- Bellini
- Bramante
- Viloft
- Galaxy
- Danufil

Tear length [m] in % versus 100% pulp

Rapid-Köthen sheets 80g/m²; Pulp: Eucalyptus 16°SR; Viscose: all fibres 3,3dtex; 6mm
Tuning of paper properties – viscose cross section

Influence of cross section → Paper porosity

Porosity of paper sheets

- 100% Pulp
- Bellini
- Bramante
- Viloft ®
- Galaxy ®
- Danufil ®

Air permeability - Bendtsen [ml/min] in % versus 100% pulp

- 2% Viskose
- 10% Viskose

Rapid-Köthen sheets 80g/m²; Pulp: Eucalyptus 16°SR; Viscose: all 3,3dtex; 6mm
Tuning of paper properties – viscose cross section

Influence of cross section → Tear resistance

Tear resistance of paper sheets

100% Viscose

10% Viscose

2% Viscose

Rapid-Köthen sheets 80g/m²; Pulp: Eucalyptus 16°SR; Viscose: all fibres 3,3dtex; 6mm
## Tuning of paper properties – viscose titer & length

### Influence of viscose fibre length and titre on paper strength

A two-level 3-Factor Full-Factorial Experiment was conducted to investigate the effects of:
- Titer
- Fibre length
- Fraction

<table>
<thead>
<tr>
<th>Titer [dtex]</th>
<th>1,7</th>
<th>3,3</th>
<th>1,7</th>
<th>3,3</th>
<th>1,7</th>
<th>3,3</th>
<th>1,7</th>
<th>3,3</th>
<th>2,4</th>
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<tbody>
<tr>
<td>Fibre length [mm]</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Fraction pulp [%]</td>
<td>100%</td>
<td>95%</td>
<td>95%</td>
<td>95%</td>
<td>95%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>85%</td>
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</tbody>
</table>

- **Tear length**
- **Tear resistance**
Tuning of paper properties – viscose titer & length

Influence of viscose fibre length and titer on paper strength

Tear resistance / tear strength

- Increasing fibre length
- Decreasing titer, decreasing fibre length

5% Danufil
15% Danufil
25% Danufil
100% Pulp

Tear resistance [mN]
Tear length [m]
Tuning of paper properties – viscose fraction

Viscose fibres: Low amounts – high impact

Tear strength of paper sheets

<table>
<thead>
<tr>
<th>% Viscose</th>
<th>1.7dtex fibre</th>
<th>3.3dtex fibre</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>0.625%</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>1.25%</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2.50%</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td>5%</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>25%</td>
<td>120</td>
<td>120</td>
</tr>
</tbody>
</table>

Tear length [m] in % versus 100% pulp

Rapid-Köthen sheets 80g/m²; Pulp: Eucalyptus 16°SR; Viscose: all fibres 4mm
Tuning of paper properties – viscose fraction

Viscose fibres: High amounts – high impact

Tear resistance of paper sheets

% Viscose 1,7dtex fibre 3,3dtex fibre

- 0%
- 0,625%
- 1,25%
- 2,50%
- 5%
- 25%

Tear resistance - Elmendorf [mN] in % versus 100%

Rapid-Köthen sheets 80g/m²; Pulp: Eucalyptus 16°SR; Viscose: all fibres 4mm
Tuning of paper properties – functionality

Paper modification with functionalized viscose fibres

Incorporation of additives

- Incorporation of pigments
- Incorporation of micro capsules
Tuning of paper properties – functionality

Paper modification with functionalized viscose fibres

Chemical modification:
- Self-bonding; ability to form paper sheets of 100% Verdi fibre
- Extremely good dispersability, Dispersion concentrations of over 5% possible without spinning and agglomeration
- Highly absorbent
- Self-extinguishing effect
- Increases retention

e.g.
- anionically modified Verdi fibre
Tuning of paper properties – functionality

Paper modification with functionalized viscose fibres

Extra absorbency

- highly absorbent Bramante fibre
  Three times higher water imbibition than regular viscose fibre
In conclusion…

- Cross section, dimensions and functionality of the viscose fibre can be modified
- Viscose fibres are a versatile tool for the control of paper and wet laid properties
- Unique ability to form sheets from 100% viscose with Bellini and Bramante fibres
- Potential to increase porosity, tear resistance and tear strength already with small percentages of viscose fibre incorporation
- Ability to introduce finished product properties through functionalized fibres
Thank you for your attention!