Enhanced Capabilities in Wet-end Paper Machine Clothing

Mikael Danielsson, Lars Martinsson
Albany International AB Sweden
David McVey
Albany International Corp. Canada
Introduction

• Increased demand for higher paper machine production and efficiencies as well as lower total operating costs has led to the development of two new concepts in Forming Fabric design

• Ultra High Fiber Support – Sheet Quality

• Surface Enhancement – Machine Runnability

• Comparison of new concepts to current standard structures

• Case stories of both separately and in combination
Key Properties of Forming Fabrics

• **Support** fiber mat, **Drainage** of water, **Transport** formed sheet to press section

• Woven structure patterns developed to enhance one or more key properties

• Publication grade machines globally today primarily run MD or CD bound self supporting binder (SSB) triple layer structures.
  - Similar trend in tissue/towel and packaging/board grades more recently
Key Properties of Forming Fabrics

• Key measures of Fiber Support and Drainage
  - # support points / cm\(^2\) or Fiber Support Index (FSI)
  - Shape of drainage channels
  - Air permeability
  - Caliper
  - Internal void volume

• Trend is almost always towards finer and thinner
SSB Evolution
Publication grades

SP (/ cm²)

High Speed Publ., SC-A

Woodfree, Newsprint, LWC

Woodfree, Newsprint

2:1 CD Ratio

1:1 CD Ratio

callper (mm)
Ultra High Support

- Developed for enhanced sheet quality
- New woven structure with increased paper side CD yarn support
- Alters CD yarn ratio from standard 2:1 to 3:1 for greater sheet support
- Benefits include sheet smoothness, print quality, porosity, fines/filler retention
Figure 1  Paper side and wear side comparison of 2:1 and 3:1 CD yarn ratio SSB structures
### Table I  Key Characteristics for the SSB structures used in the fabric/sheet contact studies

<table>
<thead>
<tr>
<th>Fabric ID</th>
<th>Paper Side Mesh x Count</th>
<th>Yarn diameters MD : CD</th>
<th>Support points</th>
<th>FSI</th>
<th>Caliper [mm]</th>
<th>Air Perm</th>
<th>CD Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MD x CD /cm</td>
<td>[mm]</td>
<td>No per cm²</td>
<td>[mm]</td>
<td>[m/s]</td>
<td></td>
<td>Top:Btm</td>
</tr>
<tr>
<td>A</td>
<td>28.5 x 39.0</td>
<td>0.13/0.21 : 0.13/0.30</td>
<td>1,130</td>
<td>180</td>
<td>0.89</td>
<td>1.50</td>
<td>2:1</td>
</tr>
<tr>
<td>B</td>
<td>34.5 x 42.0</td>
<td>0.11/0.18 : 0.11/0.25</td>
<td>1,450</td>
<td>200</td>
<td>0.72</td>
<td>1.50</td>
<td>2:1</td>
</tr>
<tr>
<td>C</td>
<td>38.0 x 43.0</td>
<td>0.10/0.17 : 0.10/0.24</td>
<td>1,635</td>
<td>210</td>
<td>0.68</td>
<td>1.50</td>
<td>2:1</td>
</tr>
<tr>
<td>D</td>
<td>28.5 x 47.0</td>
<td>0.13/0.21 : 0.13/0.30</td>
<td>1,340</td>
<td>207</td>
<td>0.85</td>
<td>1.50</td>
<td>3:1</td>
</tr>
<tr>
<td>E</td>
<td>34.5 x 58.0</td>
<td>0.11/0.18 : 0.11/0.25</td>
<td>2,000</td>
<td>255</td>
<td>0.71</td>
<td>1.46</td>
<td>3:1</td>
</tr>
<tr>
<td>F</td>
<td>38.0 x 58.0</td>
<td>0.10/0.17 : 0.10/0.25</td>
<td>2,200</td>
<td>261</td>
<td>0.71</td>
<td>1.51</td>
<td>3:1</td>
</tr>
</tbody>
</table>
Figure 2  Micro x-ray computed tomography model images of two SSB structures

Structure A: 28.5/cm Mesh
2:1 CD yarn ratio

Structure F: 38.0/cm Mesh
3:1 CD yarn ratio
Figure 3  Cross section of Fabric B (2:1 CD ratio) from paper to wear side to demonstrate the changing open area of the structure
Figure 4  Open area as a function of position or depth through the fabric
Drainage / Retention Comparison between 2:1 and 3:1 CD ratio SSB Designs

- Measured with “Juupeli” vacuum assisted sheet former
  - Measured amount of stock containing filler poured onto fabric
  - Constant vacuum level below fabric
  - Surface level monitored with ultrasonic detector for slurry thickness
  - No additional shear forces applied during dewatering
  - Repeat test method to determine process variability
- Drainage time determined
- Former sheet samples measured for fiber and filler retention
Figure 5  PCC retention and drainage time for Fabric A (2:1 CD ratio) and Fabric E (3:1 CD ratio)

- Greater sheet support (FSI) of 3:1 CD ratio design builds more uniform fiber mat without restricting drainage of smaller openings
- Drainage time slightly faster with high support design
- Retention of filler significantly higher

Tests performed on “Juupeli” vacuum assisted sheet former at VTT Technical Research Centre of Finland. Grammage 80 g/m², Eucalyptus pulp, SR030 with PCC
Surface Enhancement

• Developed for enhanced machine runnability

• Proprietary manufacturing process flattens paper side knuckles

• Densified internal void volume of structure

• Reduced overall fabric caliper

• Benefits include reduced wire knuckle mark, improved vacuum dewatering efficiency, higher couch solids, cleaner running former
<table>
<thead>
<tr>
<th>Surface Enhancement</th>
<th>Open Area at surface</th>
<th>Caliper</th>
<th>Void Volume</th>
<th>Air Perm$^{1,2}$</th>
<th>Plane difference</th>
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<tbody>
<tr>
<td>Non-Enhanced</td>
<td>39</td>
<td>0.70</td>
<td>0.57</td>
<td>1.5</td>
<td>30</td>
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<tr>
<td>Enhanced</td>
<td>37</td>
<td>0.65</td>
<td>0.55</td>
<td>1.5</td>
<td>20</td>
</tr>
</tbody>
</table>

1. ASTM D737 – 96
2. The CD-yarn density was altered for the enhanced sample in order to reach the same air perm.
Figure 6  Micro x-ray tomography model images of fabric before and after surface enhancement
Figure 7  Open area as a function of position or depth comparison for before and after enhancement process
SSB Evolution
Publication grades

Before Enhancement

After Enhancement

SP (/ cm²)

calliper (mm)
Case Stories
Case Story 1

Metso Optiformer with Loadable Blades producing SC-A Magazine grades at 1800 mpm

- Standard design Fabric B on both positions
  - 34.5/cm² mesh, 2:1 CD ratio
- 1st trial – Fabric C on both positions
  - 38.0/cm² mesh, 2:1 CD ratio
- Improvements in sheet porosity and PPS roughness, same level wet end breaks, former cleanliness

Metso and Optiformer are trade names of Metso Corporation.
Case Story 1  Sheet porosity and PPS roughness before and after set of trial Fabric C installed
Case Story 1

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  - 34.5/cm² mesh, 2:1 CD ratio
- 1st trial – Fabric C on both positions
  - 38.0/cm² mesh, 2:1 CD ratio
- Improvements in sheet porosity and PPS roughness, same level wet end breaks, former cleanliness
- 2nd trial – Fabric E on outer position, Fabric B on inner
  - 34.5/cm² mesh, 3:1 CD ratio outer
  - 34.5/cm² mesh, 2:1 CD ratio inner
- Reduced wet end breaks
- Improved top side gloss, PPS roughness and missing dots

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Case Story 1  Sheet break reduction and sheet surface improvements with High Support Fabric E on outer (top) position

**Break loss, %**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>June 08</td>
<td>B</td>
<td>53,1</td>
<td>1,1</td>
<td>1,7</td>
<td>9,0</td>
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<tr>
<td>July 08</td>
<td>E</td>
<td>55,3</td>
<td>1,0</td>
<td>1,0</td>
<td>4,5</td>
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</table>

*Lost production
Case Story 2

Voith Duoformer CFD producing LWC grades at 1250 mpm

- Standard design Fabric A on top and B on bottom positions
  - 28.5/cm², 34.5/cm² mesh, 2:1 CD ratio
- High Support Trial set – Fabric D on top and E on bottom positions
  - 28.5/cm², 34.5/cm² mesh, 3:1 CD ratio
  - Top fabric surfaced enhanced
- Increased couch solids by avg. 0.8%, press solids by 1.0%
  - Improved sheet formation and lower press draws contributed
- Steam consumption reduced 4.1%

Voith and Duoformer CFD are trade names of Voith Paper Holding GmbH & Co. KG
Case Story 2

Daily average press solids gain while running trial set of high support fabrics with the top fabric being surface enhanced
Case Story 2  
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  - 28.5/cm², 34.5/cm² mesh, 2:1 CD ratio
- High Support Trial set – Fabric D on top and E on bottom positions
  - 28.5/cm², 34.5/cm² mesh, 3:1 CD ratio
  - Top fabric surfaced enhanced
- Increased couch solids by avg. 0.8%, press solids by 1.0%
  - Improved sheet formation and lower press draws contributed
- Steam consumption reduced 4.1%
- Improved former cleanliness resulted in wet end break reduction from 2.0 to 1.4 per day avg.
- Speed increased 15 to 45 mpm depending on sheet basis weight

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Case Story 2  
Daily average wet end breaks reduced while running trial set of high support fabrics with the top fabric being surface enhanced
Conclusions

• Demands for operating efficiency gains and particularly energy consumption reductions are more critical for all paper grades regardless of size, speed or age of machine
• PMC clothing suppliers have responded by developing new structures that can enhance overall paper quality as well as operational efficiency
• Two new examples were introduced here
  - Ultra High Support structure for sheet quality
    • Formation, porosity, smoothness, print quality, fines/filler retention
  - Surface Enhancement for machine runnability
    • Vacuum dewatering efficiency, couch solids, former cleanliness, wet end breaks
• Both concepts have been proven separately and in combination on commercial publication grade machines worldwide
Questions?

Mikael Danielsson, Lars Martinsson
Albany International AB Sweden
David McVey
Albany International Corp. Canada