Practical Methods to Improve Wound Roll Quality

Neal Michal

![Diagram of wound roll with directions: MD, ZD, CD]

![Graphs showing radial and tangential stress vs. diameter]

Kimberly-Clark Corporation
Background

• Mechanical Engineer – Go Boilers!
• 28 years with Kimberly-Clark Corporation
  – Infant Care Staff & Plant Engineering
  – Infant Care Operations Team Leader
  – Nonwovens Plant & Staff Engineering
  – Two year international assignment
• KC Subject Matter Expert: Web handling, Winding, Unwinds, Converting, Process design, Automation & Modeling
• Lead KC’s 16 year partnership with the Web Handling Research Center at Oklahoma State
  – Chair, Winding Focus Team
• Partner with internal customers, external suppliers and OEM’s to develop & optimize total supply chain solutions
Wound Rolls - Overview

• Winding is an integral process for most webs
• Wound rolls are the low cost storage solution
• A wound roll is often the shipping container
• It is common to see webs compress > 25%
• Webs geometry and properties are important
• Material properties will vary thru roll & over time due to stored stress and strain
• Wound roll structure describes the shape of the stresses within the wound roll
• Your wound roll structure can be documented using simple tools
Common Defects
Wound Roll Stresses

**MD** – Machine direction stress in the plane of the web

**CD** – Cross machine direction stress in the plane of the web

**ZD** – Stress perpendicular to the plane of the web
Wound Roll Structure – Two Types

‘Soft’ Roll
- $E_t >> E_t$
- Newsprint, Creped Tissue, Spunbond, Film/SB laminate
- Plateau-type radial pressure
- Less thru-roll MD strain variation

‘Hard’ Roll
- $E_t \approx E_t$
- Film, Cast Rubber, MD Elastics, Highly Textured Tissue
- Taper-type Radial Pressure
- ‘Nike®-Swoosh’ type thru-roll MD strain variation
“Soft Roll” Structure

Interlayer Pressure
- S shaped
- Peak Pressure at the Core
- Wide Plateau Thru the Middle Plateau
- No Pressure at the Outside

Stored MD Strain
- U Shaped
- Outside layer is at web tension leading into the roll for a center winder
- Outer portion of the roll is under tension
- This compresses the inner layers in the plateau
- The layers in the plateau are stored at nearly zero tension or slightly in compression
- Pressure or strain picks back up near the core but depends on the roll start
“Hard Roll” Structure

Interlayer Pressure
- Concave parabolic curve
- Computer model prediction versus actual pull tab data
- Peak at the Core
- Decays to zero at the outside
- No middle plateau

Stored MD Strain
- Nike Swoosh™ shape
- All layers under tension
- The outside layers compress the inside layers but not enough to cause them to go into compression
- No middle plateau
Impact of More Material

‘Soft’ Roll
- Radial Pressure
- MD Stress

Addition of material has less or no effect on roll structure

‘Hard’ Roll
- Radial Pressure
- MD Stress

Addition of material has a huge effect on roll structure
Document Interlayer Pressure

- A slow speed pilot line process may allow winding tabs into the building roll.
- Many rolls will allow a pull tab to be inserted after winding.
- Simple tools are all that is required.
- Pull tab force can be converted to interlayer pressure.

<table>
<thead>
<tr>
<th>Diameter (in)</th>
<th>Force (lb)</th>
<th>Interlayer Pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.25</td>
<td>1.27</td>
<td>15.25</td>
</tr>
<tr>
<td>9.75</td>
<td>1.06</td>
<td>12.75</td>
</tr>
<tr>
<td>10</td>
<td>0.92</td>
<td>11.00</td>
</tr>
<tr>
<td>11.25</td>
<td>0.85</td>
<td>10.25</td>
</tr>
<tr>
<td>12.25</td>
<td>0.78</td>
<td>9.00</td>
</tr>
<tr>
<td>13</td>
<td>0.67</td>
<td>8.00</td>
</tr>
<tr>
<td>15.25</td>
<td>0.58</td>
<td>7.00</td>
</tr>
<tr>
<td>17.25</td>
<td>0.54</td>
<td>6.50</td>
</tr>
<tr>
<td>19</td>
<td>0.52</td>
<td>6.25</td>
</tr>
<tr>
<td>21.25</td>
<td>0.46</td>
<td>5.50</td>
</tr>
<tr>
<td>23.25</td>
<td>0.46</td>
<td>5.50</td>
</tr>
<tr>
<td>25.25</td>
<td>0.46</td>
<td>5.50</td>
</tr>
<tr>
<td>27.25</td>
<td>0.46</td>
<td>5.50</td>
</tr>
<tr>
<td>29.25</td>
<td>0.42</td>
<td>5.00</td>
</tr>
<tr>
<td>31.25</td>
<td>0.38</td>
<td>4.50</td>
</tr>
<tr>
<td>33.25</td>
<td>0.33</td>
<td>4.00</td>
</tr>
<tr>
<td>35.25</td>
<td>0.29</td>
<td>3.50</td>
</tr>
<tr>
<td>37.25</td>
<td>0.25</td>
<td>3.00</td>
</tr>
<tr>
<td>39.25</td>
<td>0.25</td>
<td>3.00</td>
</tr>
<tr>
<td>41.25</td>
<td>0.25</td>
<td>3.00</td>
</tr>
<tr>
<td>43.25</td>
<td>0.21</td>
<td>2.25</td>
</tr>
</tbody>
</table>
Document Machine Direction Strain

- There are two methods to document stored MD strain
  - Measure repeating patterns on your web
  - Print registration marks before the winder
- Calculate strain on roll & off roll
Methods to Improve Delivered Quality

“Uhhh... Why are you looking at me?”
Monitor Your Winding Process

- Document how your winding process works: tension, nip, torque
- Develop scientific based measurements for your settings
- Develop targets and limits for your settings and validate
- Document process settings daily
- Set up trend charts to monitor settings & alarm if outside limits
- Document your wound roll structure at target and at limits
- Understand how your inputs change your roll structure
- Set up daily process health cleaning to reduce unplanned events
• Invest in good material testing techniques
• Use Elastic Limit to determine which control method to use
• Tension control is best for stiff webs (EL < 3% Strain)
• Draw control is best for stretchy webs (EL > 3% Strain)
Average Wound Roll Density

\[
\rho \left( \frac{lb}{ft^3} \right) = (3) \times \frac{BW \times L}{\left( \frac{OD^2}{4} - \frac{ID^2}{4} \right) \times \pi}
\]

- For compressible webs roll density is a very sensitive measurement of your entire process
- Average roll density calculations only require three terms
  - Basis weight, Length, Diameter
- Set up trend charts; react when outside limits
- Wound roll structure is repeatable for a given density
Caliper Loss

- Caliper loss is inversely proportional to interlayer pressure
- Document and control density
- Reduce winding tension and nip to reduce density
- Tare out the weight of the coreshaft using offsetting pressures
- Reduce web temperature below room temp before the winder
- Reduce storage temperature; consider refrigerated shipping
- Increase core diameter where possible
- Consider modifying the upstream process to loss near the core
Internal Roll Slippage

- Low torque capacity causes roll slippage
- Torque capacity is at min near the core
- Document your slip plane diameter
- Measure torque capacity using a fixture
- Document density & internal layer pressure
- Eliminate sudden changes in tension & nip
- Increase roll density
- Increase tension and/or nip beyond the slip plane
- Consider increasing core diameter
- Use less accel / decel in converting
- Improve your unwinding process
Floppy Edges

- Floppy edges, cambered webs, and baggy lanes are often the same defect.
- #1 Cause: CD basis weight variation
- Others: Temp, Moisture, Forming, etc.
- Improve your CD BW profile
- Reduce web temp below room temp
- Reduce roll density
- Reduce time & temp in storage
- Wind loose, allow aging, rewind to final roll density
- Wind a sacrificial layer when required
Slit Width Growth

- MD strain profile thru roll causes some materials to grow in width due to Poisson’s ratio
- Reduce roll density
- Reduce web temperature
- Reduce time & temp in storage
- Consider refrigerated storage or shipping
- Use a large taper tension during the last ~10% of roll length
Tips on Process Optimization

- Until you use dollars you will not make sense
- Fallacy of “Don’t fix it if it is not broken”
- Don’t jump to conclusions; follow the facts
- Make direct observations
- Be humble & ask many questions
- Collaborate with many; trust but verify
- Gain trust with the machine operators & ask for their help
- Use the “Shape Tool” to filter the evidence you collect
- Use advanced tools: trend charts, cameras, FFT analysis, ect
- Educate yourself: Good, Pagilla, Roisum, Walker, Lucas….
- Attend “Applications Seminar on Web Handling” @ OK State
- Consider joining the Web Handling Research Center @ OK State
Questions?

Neal Michal
Global Nonwovens
nmichal@kcc.com
(770) 356-7996