Recent Advances in Rubber Roll Covers for Improved Paper Machine Performance and Reduced Energy Requirements

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Topics

• Rubber Chemistry/Physical Properties
• Applications
  - Press Rolls
  - Size Press Rolls
  - Yankee Pressure Rolls
  - Coater Backing Rolls
• Conclusions
Structure of a Cured Rubber

- Long polymer chains
- Mainly synthetic
- Have sites for crosslinking
- Different chemicals are incorporated for optimum physical and mechanical properties
Types of Rubbers

- **NBR** - Resistant to aliphatic and aromatic solvents. Best combination of physical properties and solvent resistance.

- **HNBR** - Resistant to aliphatic and aromatic solvents. Ozone resistance. Higher temperature rating than NBR.

- **CSM** – High temperature applications. Excellent resistance to strong chemicals and natural aging. Resistance to oils, solvents, and ozone. Excellent release behavior.

- **EPDM** - Good aging properties. Good resistance to steam and oxygenated solvents. Heat resistance.
Rubber Formula Ingredients

- Rubber matrix
- Filler - Carbon Black, Silica, Clay, nano-fillers, fibers etc. - Reinforcement
- Antioxidant - Prevents oxidation of the rubber so it does not degrade (crack or harden).
- Plasticizer - Different kinds of oils – Helps processing and softens rubber.
- Crosslinking agent - Peroxide or Sulfur – controls hardness and improves the properties of the rubber.
- Other Misc. Additives
Compounding and Mixing

2-roll mills to blend rubber components
Physical Property Testing

- P&J – Pusey and Jones Hardness
- Abrasion resistance
- Tensile and elongation at break
- Tear strength
- Compression set
- Hysteresis
- Dynamic modulus
- Chemical resistance
Press Rolls

• Typically 15 to 25 P&J high performance rubber covers
  - Engineered Dri-Press® venting
• Required cover properties
  - Superior wear resistance to maintain crown profile and hole geometry
  - Low hysteresis to run cool
  - Superior toughness to withstand impacts at high loads without cracking
  - Superior bonding system
  - Excellent chemical resistance
Press Rolls

**Hysteresis**

- Hysteresis is the amount of heat generated by a material as it is cyclically loaded and unloaded
- Calculated by area of the hysteresis loop (MTS)
- Lower hysteresis is desirable
- Used in material development
- Results in materials that run at lower temperatures
Press Rolls
Tear Strength

High tear strength of new cover technology withstands high impacts and avoids hole to hole cracking in drilled rolls.
Case History- Press Roll
NA Pulp Machine

<table>
<thead>
<tr>
<th>Press</th>
<th>Line Load, Speed</th>
<th>Current conditions, water cooled</th>
<th>Proposed, non-water cooled</th>
<th>Water savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st press</td>
<td>96 kN/m, 183 m/min</td>
<td>0 PJ Steel top/ 20 PJ Rubber cover</td>
<td>70 PJ top/ 20 PJ</td>
<td>12 L/min</td>
</tr>
<tr>
<td>2nd press</td>
<td>149 kN/m, 183 m/min</td>
<td>20 PJ/20 PJ Rubber</td>
<td>30 PJ/30 PJ</td>
<td>14 L/min</td>
</tr>
<tr>
<td>3rd press</td>
<td>280 kN/m, 183 m/min</td>
<td>18 PJ/18 PJ Rubber</td>
<td>21 PJ/ 21 PJ</td>
<td>16 L/min</td>
</tr>
</tbody>
</table>

Press Roll Conditions and Water Savings

![Nip Width Graph](image1)

![Nip Intensity Graph](image2)
Case History Results- Superwear Xtreme®

• Removal of water cooling: Savings in water and maintenance of $55,000/ year
• Increase in nip intensity and dwell time provided 1% dryer sheet entering the dryer
  - steam reduction of 10%
  - $200,000/ year savings
• Much longer runtime
  - 6 months vs 3 years
• No hole to hole cracking
• No chemical attack on the roll surface
Case History: A Soft Press

Problem / Opportunity
- Decrease cover hardness to increase press loading
- Improve sheet solids
- Improve sheet bulk

Resolution
- Install 40 P&J new technology cover with Dynamic nip technology in 1st press bottom
- Increase press loading
- Use Dynamic nip technology® Roll to flatten nip at increased load.

Value
- Increased sheet bulk
- Reduced fiber usage by 3-4%
- Improved CD moisture and caliper profile
- $700,000 sign off

Machine Type: Trinip
Grade: Bleached Board
Speed: 365 mpm (1200 fpm)
Load: 45 Kn/m (250 PLI)
Size Press Rolls

• Soft size press rolls typically 20 to 45 P&J rubber covers
• Hard size press rolls typically 0-1 P&J rubber covers
• Required cover properties
  - High wear resistance to maintain surface profile and longer run time
  - Chemical resistance
  - Hardness stability
  - Minimal thermal crown growth
  - Mark Resistant
Size Press Rolls

• Roll Cover Design
  - Sheet follows hard roll with smooth or 0.8 – 1.6 µm (20-40 µ-in) Ra finish
    • Smoother finish maintains more intimate contact
    • Soft roll deformation results in surface velocity change in the nip
    • Hard roll deforms less thus maintaining more constant contact
  - Soft roll ground to or 1.2 – 2.0 µm (30-50 µ-in) Ra.
  - Adequate wetting balance between sheet and size
Film Press Case History – Misting Study

Misting test: LWC, 1800 m/min, 8 g/m²
Old Technology cover(left) / New Technology cover(right); 50/50 P&J

Paper top side to the right

Paper top side to the left

Misting stays on Old Technology cover side
Film Press Case History – Misting Study
Supersize XL®

Misting test: LWC, 1800 m/min, 8 g/m²
New (left) / New (right); 50/50 P&J

Paper top side to the right

Paper top side to the left

No misting with two New Technology covers
Tissue Pressure Rolls

• Typically
  - 30 to 45 P&J high performance rubber covers
  - Engineered venting

• Required cover properties
  - Superior wear resistance to maintain crown profile and hole geometry
  - Excellent chemical resistance
  - Superior bonding system
  - Hardness stability
New Tissue Pressure Roll Covers

- Suction pressure roll and blind drilled pressure roll
- Excellent abrasion resistance
- Excellent hardness stability
- Superior bonding system
- Cooler running covers able to run non-water-cooled
Structure of Cured Rubber and Causes of Hardening

- Oxygen/Ozone
- Temperature
- Loss of Processing aids
- Chemical Attack

Double bonds, Site for further crosslinks
Hardness Stability - Hyperpress X®

5.0 cm thick samples, 100 °C Oven
# Case History – Xtreme TS®
**NA Tissue Machine**

<table>
<thead>
<tr>
<th>Material</th>
<th>Cover Thickness (cm)</th>
<th>Max Stress (kPa)</th>
<th>Max Temp., bond line (°C)</th>
<th>Required cooling water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>2.54</td>
<td>2032</td>
<td>89</td>
<td>24L/ min</td>
</tr>
<tr>
<td>New</td>
<td>2.54</td>
<td>2108</td>
<td><strong>76</strong></td>
<td>none</td>
</tr>
</tbody>
</table>

**Load**: 79 kN/m (450 pli)
**Machine Speed**: 1860 m/min (6100 fpm)
**Cover Diameter**: 76.2 cm (30”)
**Cover Face Length**: 3.25 m (128”)
**Surface Temperature**: 49 °C (120 °F)

Significant drop in operating temperature

Water Cooled

Non-Water Cooled
Coater Backing Rolls

• Typically
  - 45 to 95 P&J rubber covers

• Required cover properties
  - High wear resistance
  - Excellent resiliency
  - Chemical resistance
  - Mark resistance
  - Hardness stability
  - Crack and tear resistance
  - Surface release properties
Coater Backing Rolls
Abrasion Resistance

![Bar chart showing abrasion resistance comparison between Rubber #1, Rubber #2, and New Cover. Rubber #2 has the highest resistance, followed by New Cover, and then Rubber #1.]
Case Histories- Hypercoat®
Coater Backing Roll

Improved Run Times

- Board Mill
  - Increased run time 90 to 180+ days
  - Edge cracking eliminated
- LWC Mill
  - Increased run time 90 to 200 days.
- Coated Paper
  - Mill increased run time from 45 to 75+ days
Base Technology for High Performance Applications

• **Lifegard II®** base technology – high performance, non-water-cooled applications
  - Excellent hardness stability
  - Superior bonding system
  - Cooler running covers
  - All press roll applications

Advantages
- Water and energy savings
- Lower maintenance cost
- Avoid water diffusion related failures
An Example: Coated Board Machine

Mill Problem

• Water diffusion related cover failures
• 70 gpm water cooling rate for 2 rolls
• Temperature controlled to 130 F
• Water cooling required constant maintenance

Solution

• Apply new non-water cooled base technology

Results

• 1.5 roll cover savings annualized
• Machine downtime minimized
• $200K annualized savings
Conclusions:

• The improved performance of several rubber covers in Press, Size Press, Yankee Pressure, and Coater Backing rolls have been illustrated.
• Improved covers are running longer in the machine.
• Covers with low hysteresis along with high temperature base system allow roll to run under non-water cooled conditions. It saves energy, maintenance, and the cost of water.
• Case histories were discussed regarding energy savings.