Web 101.15\textsuperscript{SM} – Nip Load Quality Control

Nip Impressions

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Nip - Definition

• What
  – Two parallel rollers running against each other

• How
  – Load control (cylinder force)
  – Position control (cylinder forced to stops)

• Why
  – Web Transport (move)
  – Web Processing (modify)
Nips

Transport (move web)
• Pull Rollers
• Winding

Process (modify web)
• Calendering
• Coating
• Corrugating
• Embossing
• Laminating
• Printing
• Rolling
• … etc
Nip Themes

• Underlying physics applies to all nips
  – See Mechanics of Rollers and other literature

• A uniform nip is vital for a uniform product
What the Web Sees

- A pressure pulse
  - Nip width called ‘footprint’
  - Peak pressure
    - Sometimes does the ‘work’
  - Nip Load
    - Sometimes does the ‘work’
    - Area under curve
    - Force imposed by machine
    - Process setting
  - Impulse (pressure x time)
  - Duration (width / speed)
Peak P from Nip Width

- Measure or calculate linear nip load $p$ (lb/in)
- Measure contact width $b$ (in)
  - Nip impression paper
  - Sticky notes
  - Ruler
- Calculate peak pressure $\sigma_{\text{max}}$ (lb/in$^2$) = $1.277 \times \frac{p}{b}$
Nip Control

- **Load Control by Cylinders**
  - Calendering, Pressing, Rolling
  - Winding
  - Etc

- **Position Control by Stops**
  - Coaters
  - Printers (many)
  - etc
Load Control

- **Load Force** is controlled by **Cylinders**
Nip Control Variation

• Load Control Variation Sources
  – Cylinder Friction (pneu vs hyd)
  – Control Valve Hysteresis
  – Pivots/Slides etc

• Load Variation Measurement
  – Measure Open Pressure
  – Measure Close Pressure
  – Calculate Uncertainty from the Difference
Nip Quality Measure Example

- Pressures
  - 60 PSI Run
  - 50 PSI Raise
  - 40 PSI Lower
- Control P = 60 – 50 = 10 psi
- Uncertainty P = 50 – 40 = 10 psi
- Pk-Pk variation = 100 %
Nip Load Control Sanity

• Nip Load Zero (0 on dial = 0 nip)
  – Bias pressure one side of cyl cancels weight
  – Control pressure on other side of cyl
• Nip Load Calibrated in lb/in or kN/m
  – Overlays on Pressure Gage
  – PLC Calculation
• Nip Load Side-to-Side Bias
  – Two edged sword
Gap/Interference Control

- Position is controlled by Stops

Diagram:
- Fixed Roller
- Positioned Roller
- Top Taper Half
- Bottom Taper Half
- Thread
- Nut
- Hand Crank or Stepper Motor
- Gap or Interference
Position Control Variation

- Variation in
  - Web caliper etc
  - Roller runout
- Hysterisis of Stops
  - Backlash
  - Compliance
- Values
  - Adjustable to millionths of an inch
  - Repeatable to thousands of an inch
Nip Variation Sources

- Roller Radial Runout
- Roller Diameter Variations
- Roller Shell Wall Deflection
- Cover Hardness Variations
- Loading System Variations
- Roller Misalignment
- Roller Deflection
- Roller Crown/Load Mismatch
Roller Radial Runout

- Bumps cause vibration
- Bumps may cause product Barring
- Bumps may resonate or even self-excite
- Measured as TIR (Total Indicator Runout)
- Measured with a dial indicator

\[ \∏ \times \text{Dia} \]
Roller Diameter Variation

- Measured with a caliper, saddle mic etc
- Measurements
  - Peak-to-peak (maximum variation across roll)
  - Station-to-station (maximum gradient)
    - Usually most problematic
Roller Shell Wall Deflection

- Aka ‘Oil Canning’
- Thin wall bends like a squeezed pop can
- Wall may be thin when $t < \frac{\text{Dia}}{20}$

More Info: MOR pp 80 15.17
Cover Hardness Variations

- Covers may vary in hardness across the width due to nonuniform manufacturing.
- Covers may change hardness nonuniformly due to local hardening.
- Hardness of quality covers usually varies less than 5% (P&J or Durometer).
Roller Misalignment

- **Position Misalignment**
  - Unintentional roller misalignment w very stiff x-tie
  - Intentional? biased adjustments of stops

- **Load Bias**
  - Intentional bias of load settings
  - Unintentional bias of friction, weight etc
Roller Deflection

- Roller deflect under nip load
- Causes a bowing away in the center
Crown/Load Mismatch

- A crowned or barrel shaped roller can be cut to fill in the ‘gap’
- However, crown is only correct for one load

More Info: MOR pp 32,33,81,82
Nip Deflection Compensation

- Roller Diameter Increase
- Roller Journal Length Decrease
- Crowning
- Skewing
- Journal Bending
- Thermal Profiling
- ‘Swimming’ Rollers
Nip Quality Control Checks

• Roller Radial Runout
• Roller Diameter Variations
• Roller Shell Wall Deflection
• Cover Hardness Variations
• Loading System Variations
• Roller Misalignment
• Roller Deflection
• Roller Crown/Load Mismatch
Nip Impression

- **Static**
  - Close gap only
  - Most common
  - Most versatile
  - Least Sensitive

- **Dynamic**
  - Roll Through Gap
  - Most Sensitive
Reading Nip Impressions

<table>
<thead>
<tr>
<th><strong>Static - Nip Width</strong></th>
<th><strong>Dynamic - Nip Pressure (color)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Crown Too Low for Given Load</td>
<td>Crown Too Low for Given Load</td>
</tr>
<tr>
<td>Crown Too High for Given Load</td>
<td>Crown Too High for Given Load</td>
</tr>
<tr>
<td>Unbalanced Loading or Misaligned</td>
<td>Unbalanced Loading or Misaligned</td>
</tr>
<tr>
<td>Banding - Roller Wear, Grinding</td>
<td>Banding - Roller Wear, Grinding</td>
</tr>
</tbody>
</table>

15.25
Nip Impression Materials

- 1 and 2 component carbonless papers
- 1 and 2 component films (Pressurex)
- Embossed foil
- Sources
  - Sensor Products Inc.
  - (Paper) Machinery Builders
Other Nip Checkups

• Simple
  – Sticky Note gaps
  – Grease bag gaps
  – Flashlight test

• Electronic
  – Electronic Nip Impression
  – Pressure sensitive sensors FSR

• Roller
  – Saddle micrometer
  – Laser micrometer
Nip PM

• Typical
  – Customer complains about streaks
  – Brainstorm possible nip nonuniformity
  – Where is nip paper?
  – Order nip paper
  – Nip uneven

• PM
  – Old roller condition – probably bad
  – New roller condition – should be OK
  – Mid life roller condition - this is PM
    • Roller ID and history folder
Nip Impression Safety

- Nip impressions should not be taken unless all people involved have been trained and tested in machine safety and nip impression safety.
- Nip impressions should not be taken unless all people involved can and will take all precautions such as listed here.
- The nip should not be closed until the operator has made certain that all personal are clear.
- The nip should not be closed until the operator has a clear view of the entire length of both sides of the nip.
- The nip should not be closed until the operator has loudly yelled “Closing Nip” and waited for at least 5 seconds.
- The drive should not be engaged until the operator has made certain that all personal are clear.
- The drive should not be engaged until the operator has a clear view of the entire length of both sides of the nip.
- The drive should not be engaged until the operator has loudly yelled “Drive On” and waited for at least 5 seconds.
- Consult your plant and machine builder for lockout tag out procedures for your machine.
- The nip must be blocked open when personnel are inside the machine.
CLICK TO RETURN TO LIST OF PAPERS AND PRESENTATIONS