The negative impact of uneven calendering on web properties and strength

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Outlines

- Purpose of calendering
- How does non-uniform calendering affect web properties
- Strength uniformity vs web breaks
- Roll grinding performance measures vs calender rolls out-of-roundness
- Case study: how changes in grinding techniques led to round rolls and reduce variability (and web breaks)
Why are Calenders Needed?

- Develop surface properties
- Control thickness
- Build the reel

- Thickness reduction = Densification
- Surface replication = Smoothing
Calender Stacks - Example

Paper machine calender

- Heated
- Variable crown
- Driven

- On-line or off-line
- 1 to 12 nips or more
- Nip load: 50-200 kN/m
- Temp.: 40 to 100°C
- One or more stacks
The Importance of Getting Uniform Properties

- Improving uniformity:
  - Less web breaks (less weaker zones)
  - Less quality issues
  - Less customer complaints/claims

- The most affected properties by non-uniform calendering
  - Gloss
  - Thickness
  - Strength
What Controls Web Breaks?

- Local strength of web
- Press tension variation
- Web strength distribution
- Press and converters related factors
- Risk of web breaks

Web Related Factors:
- Average MD Strength
- Strength variation
- Defects (wrinkles, holes, ...)
- Tension
- Tension variation

Press and Converters Related Factors:

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What is Strength Uniformity?

- Many webs (like paper) are non-uniform material
- Tensile strength tends to follow Weibull distribution
  \[ F(T) = 1 - \exp\left[ - \left( \frac{T}{T_s} \right)^m \right] \]
- Weibull modulus (m factor) is strength uniformity parameter
- The higher the \( m \) value, the better the strength uniformity

Tensile Distribution

Higher uniformity
\( m = 20 \)

Lower uniformity
\( m = 12 \)
Web Break Rate vs. Strength Uniformity

![Graph showing the relationship between m-factor and break rate. The graph suggests that as the m-factor increases, the break rate decreases, indicating better strength uniformity.]
Quantification of Strength Variability

- Tensile strength analysis are completed with Instrom apparatus
  - Tensile tests at 1 m interval in MD

- Characterize average strength and strength uniformity
  - Calculate MD tensile, MD stretch, MD TEA and strength uniformity factor

- Benchmark strength properties against other mills (in-house database)
MD Tensile Variations

![Graph showing MD Tensile Variations with Caliper and MD Tensile lines fluctuating over distance in MD (cm)].
Quantification of Properties Variability

- Tapio is a high accuracy and high resolution apparatus that measures web properties in MD (and CD).
  - MD resolution: 12.8 mm
- Property measurement of:
  - Basis weight (30 g/m² - 800 g/m²)
  - Thickness (up to 500 μm)
  - Ash content (g/m²)
  - Gloss top and bottom (%)
Thicknes Variability Due to Barring

MD caliper

FFT of MD caliper

Frequency associated to calender barring
Wavelength = 2.1", Amplitude 10-15 um (0.0004-0.0006")
Strength Uniformity vs Calendering

- In our research, it was found that strength uniformity is mostly affected by pulp furnish variations and by calendering operations.

- Calender rolls roundness after grinding is an issue for many mills.
Rolls Regrinding – Performance Measures To Get Round Rolls

- Example for a modern high speed paper machine:
  - Concentricity within 0.0002”
  - Roundness within 0.0002”
  - Residual barring amplitude less than 0.00005”
Quantification of Roll Roundness

- Round roll
  - LVDT value
  - Angular position

- Oval roll
  - LVDT value
  - Angular position

- Roll with barring
  - LVDT value
  - Periodic signal
  - Angular position
Round vs Oval Profiles Measured

Rouleau 46 avant

Rmax-Rmin = 0.00021”

Rouleau 13 arriere

Rmax-Rmin = 0.00186”
Roll Surface With and Without Barring

With barring

Roll CS-543: front
Line spacing = 0.0001 in

No barring

SC11 Roll 5: front
Lines spacing = 0.0002 in
Case study: Significantly Lower Strength Uniformity and Higher Web Breaks
Where Do The Variations Come From?

FFT analysis shows that tensile variation is related to the caliper variation created by calendering.

Variation in caliper and tensile every rotation of the King roll.
The thickness of the shell varies, from 0.004” to 0.007” because of the inner shell eccentricity.
Correction of Inner Shell Eccentricity

STD grinding procedure

Modified grinding procedure with application of performance measures for regrinding
Strength Improved After Re-grinding Calender Rolls (No More Cycle)
Strength Uniformity Improved After Re-grinding Calender Rolls

Before

After

m-factor

11/02/09 11/05/09 11/08/09 11/11/09 11/14/09 11/17/09 11/20/09

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Feedback From Customer:
50% Reduction in Web Breaks

Mill B

Break Rate (%)

Before    After

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Summary

- **Calender rolls out-of-roundness can negatively affect web properties**
  - Up to 20-25% variations in caliper and gloss
  - Up to 15-20% variations in strength

- **Significant strength variations increase web breaks**
  - Quality and performance issues
  - Customers complaints/claims/loss

- **Calender rolls re-grinding:**
  - Calender rolls must be reground with care to achieve roundness and concentricity tolerances required by the process
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