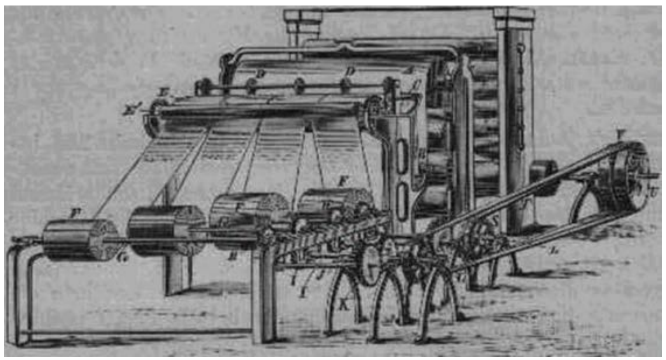
Practical Methods to Improve Wound Roll Quality



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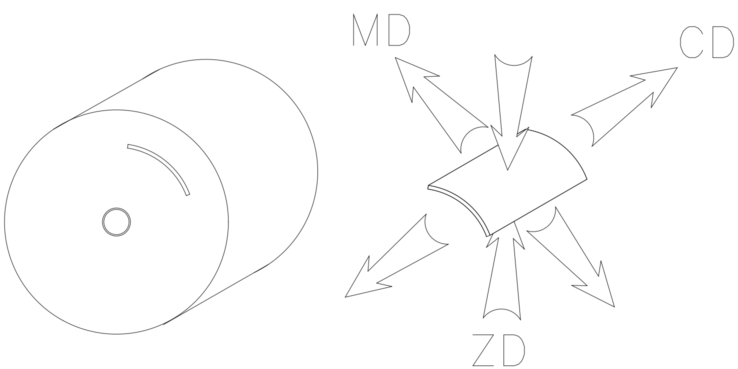
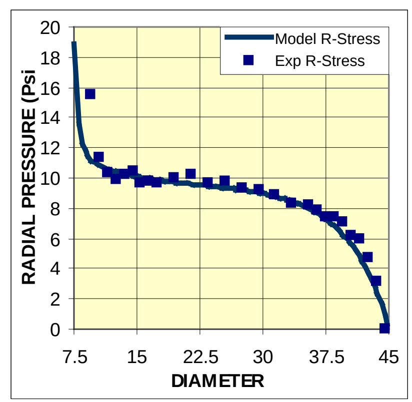
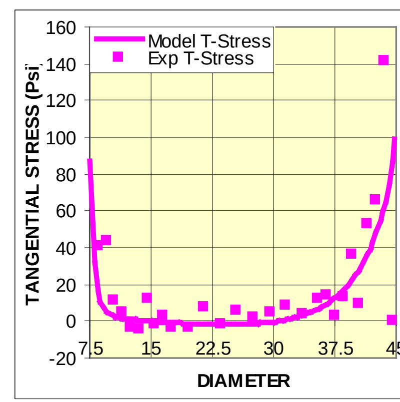






Kimberly-Clark Corporation

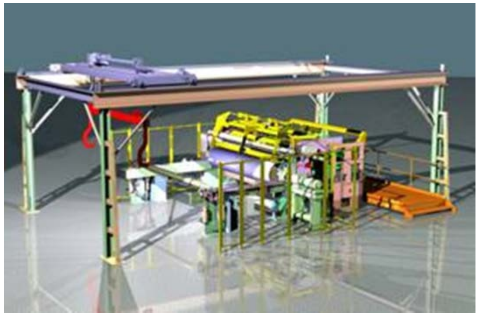
Background

- 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

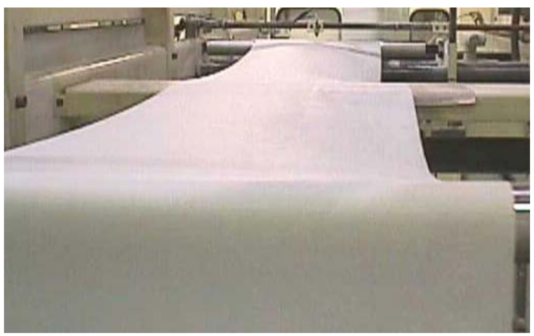
- KC Subject Matter Expert: Web handling, Winding, Unwinds, Converting, Process design, Automation & Modeling
- Lead KC's 16 year partnership with the Web Handling Research Center at Oklahoma State
  - Chair, Winding Focus Team
- Partner with internal customers, external suppliers and OEM's to develop & optimize total supply chain solutions

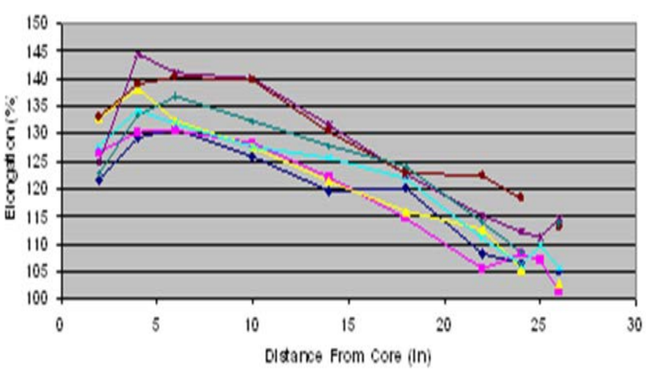
Wound Rolls - Overview

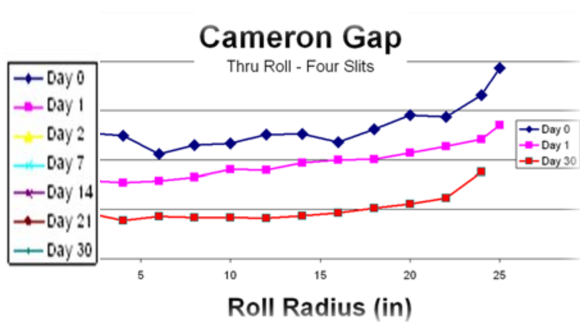
- Winding is an integral process for most webs
- Wound rolls are the low cost storage solution
- A wound roll is often the shipping container
- It is common to see webs compress > 25%
- Webs geometry and properties are important
- Material properties will vary thru roll & over time due to stored stress 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

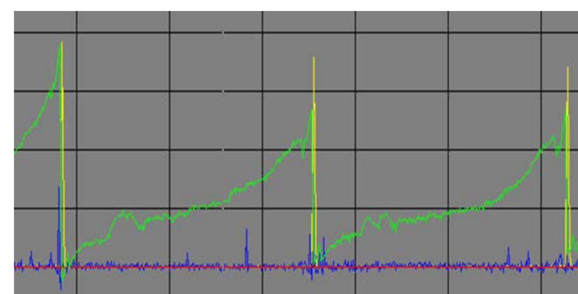


Common Defects

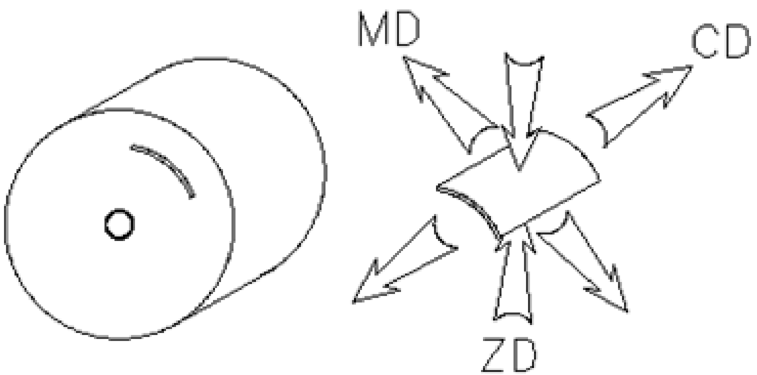


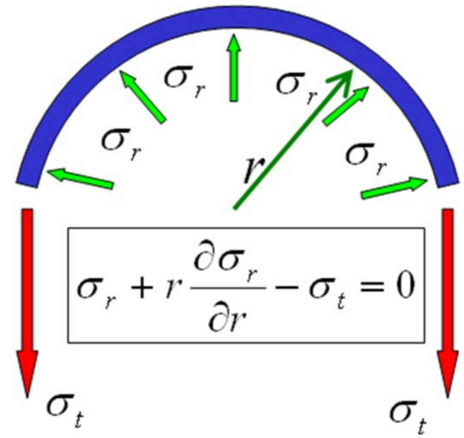






Wound Roll Stresses





MD – Machine direction stress in the plane of the web

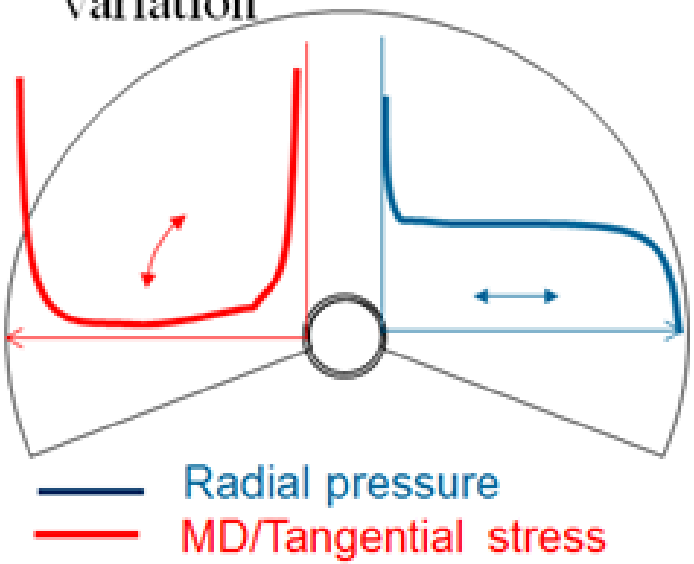
CD – Cross machine direction stress in the plane of the web

ZD – Stress perpendicular to the plane of the web

Wound Roll Structure – Two Types

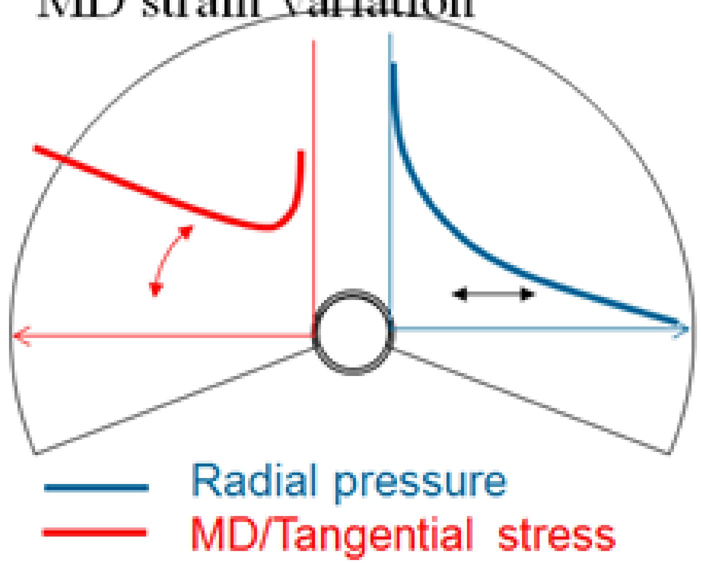
‘Soft’ Roll

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



‘Hard’ Roll

- $E_t \cong E_r$
- Film, Cast Rubber, MD Elastics, Highly Textured Tissue
- Taper-type Radial Pressure
- ‘Nike®-Swoosh’ type thru-roll MD strain variation



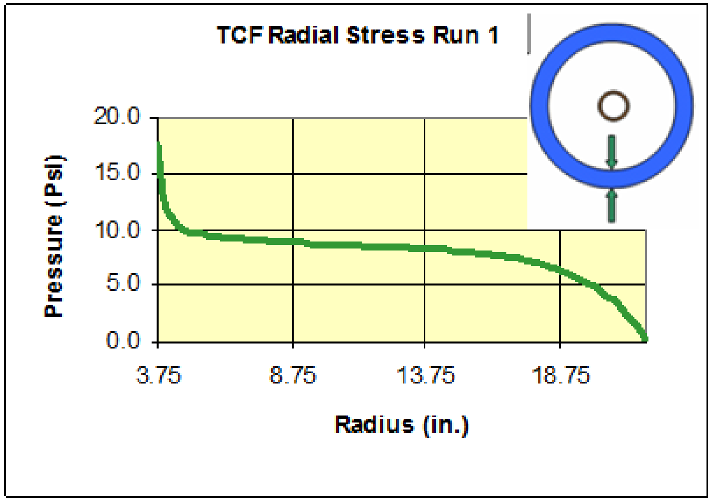
"Soft Roll" Structure

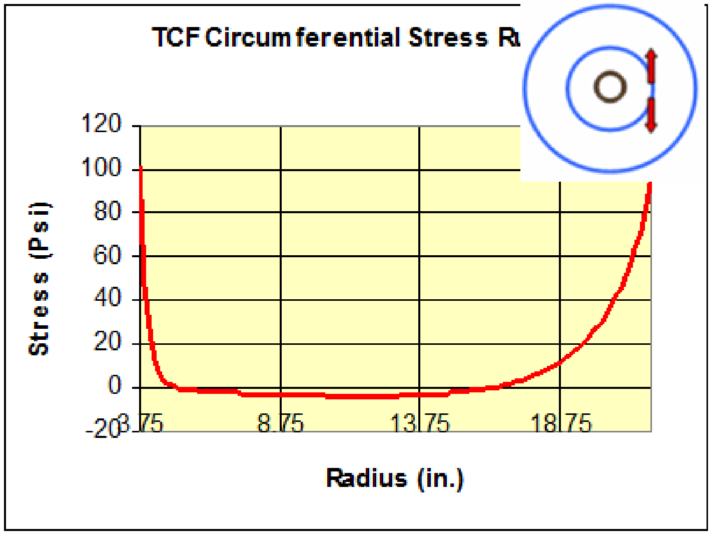
Interlayer Pressure

- 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

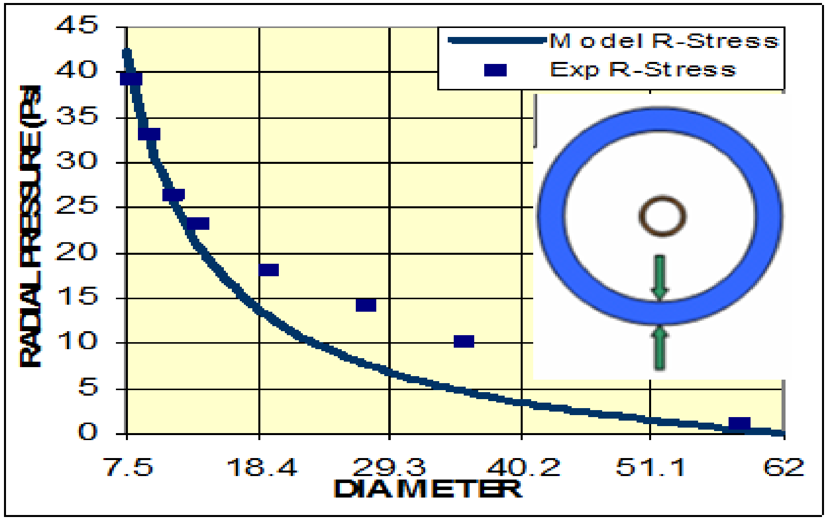




“Hard Roll” Structure

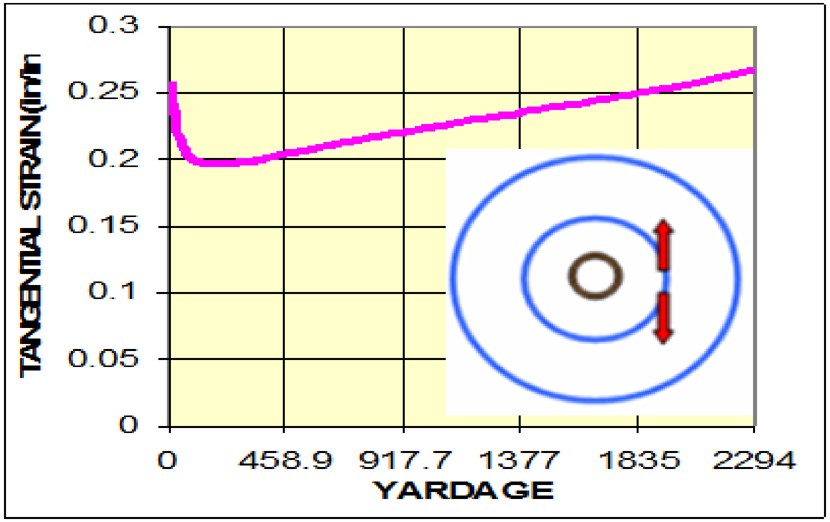
Interlayer Pressure

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

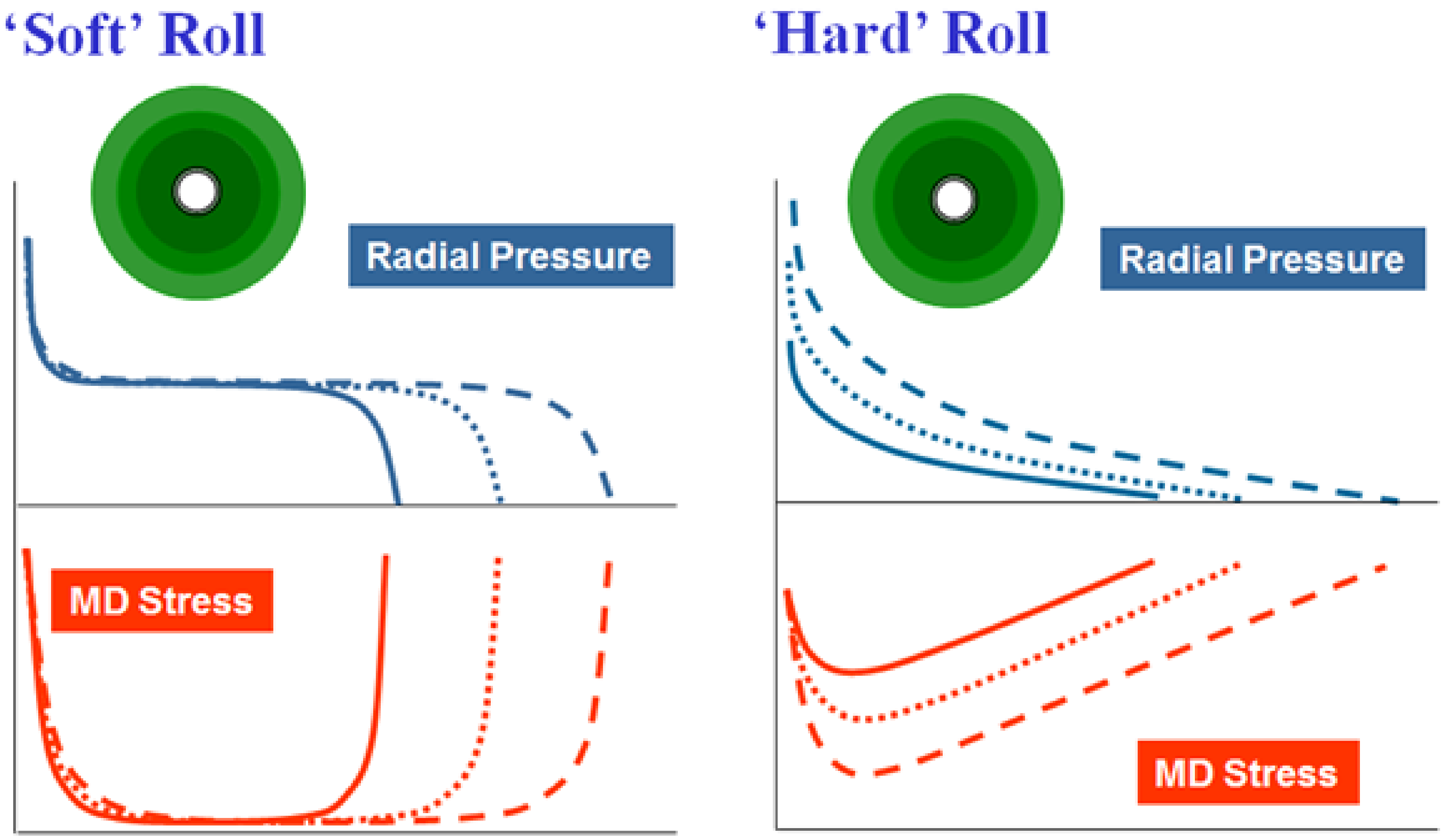


Stored MD Strain

- 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



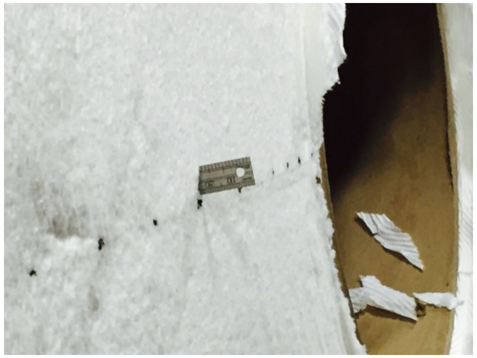
Impact of More Material



Addition of material has less or no effect on roll structure

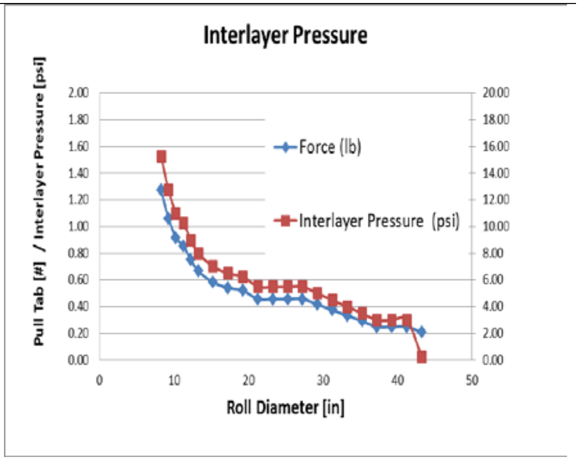
Addition of material has a huge effect on roll structure

Document Interlayer Pressure

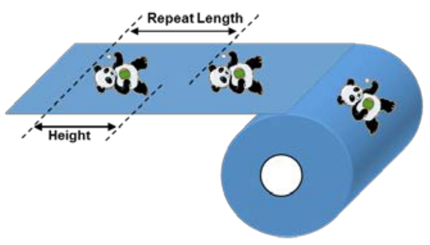


- A slow speed pilot line process may allow winding tabs into the building roll.
- Many rolls will allow a pull tab to be inserted after winding
- Simple tools are all that is required
- Pull tab force can be converted to interlayer pressure

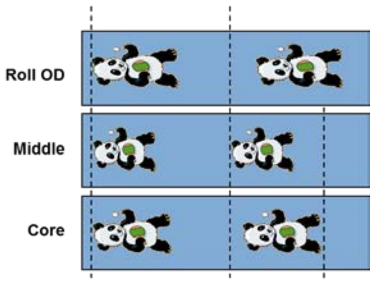
Diameter (in)	Force (lb)	Interlayer Pressure (psi)
8.25	1.27	15.25
9.25	1.06	12.75
10.25	0.92	11.00
11.25	0.85	10.25
12.25	0.75	9.00
13.25	0.67	8.00
15.25	0.58	7.00
17.25	0.54	6.50
19.25	0.52	6.25
21.25	0.46	5.50
23.25	0.46	5.50
25.25	0.46	5.50
27.25	0.46	5.50
29.25	0.42	5.00
31.25	0.38	4.50
33.25	0.33	4.00
35.25	0.29	3.50
37.25	0.25	3.00
39.25	0.25	3.00
41.25	0.25	3.00
43.25	0.21	0.25



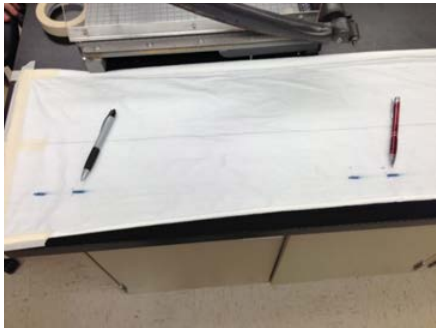
Document Machine Direction Strain



During Winding

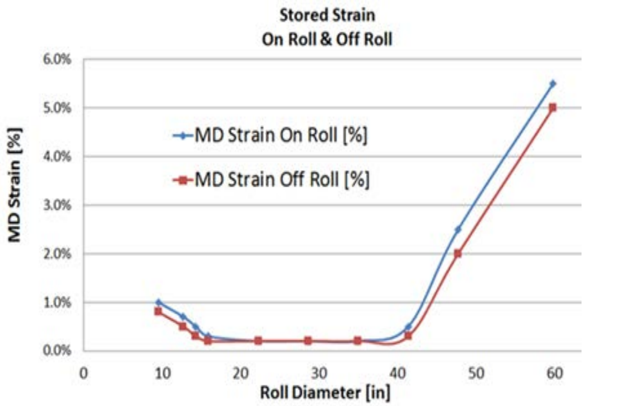


After Winding (On or Off Roll)

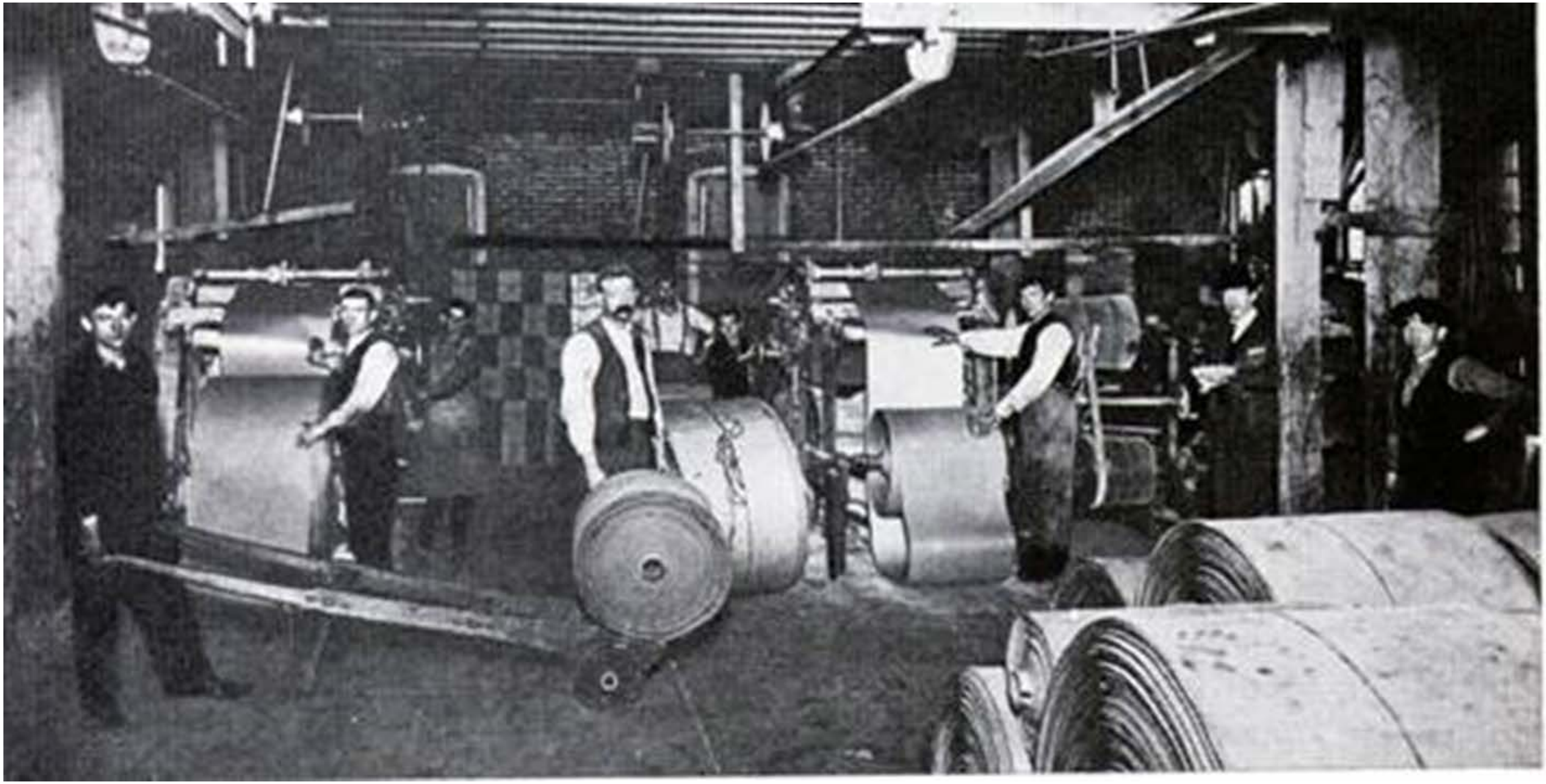


- There are two methods to document stored MD strain
  - Measure repeating patterns on your web
  - Print registration marks before the winder
- Calculate strain on roll & off roll

Circumference [in]	Dia [in]	Dia [mm]	On Roll Repeat [mm]	Off Roll Repeat [mm]	MD Strain On Roll [%]	MD Strain Off Roll [%]
188	59.8	1520.0	1055	1050	5.5%	5.0%
150	47.7	1212.8	1025	1020	2.5%	2.0%
130	41.4	1051.1	1005	1003	0.5%	0.3%
110	35.0	889.4	1002	1002	0.2%	0.2%
90	28.6	727.7	1002	1002	0.2%	0.2%
70	22.3	566.0	1002	1002	0.2%	0.2%
50	15.9	404.3	1003	1002	0.3%	0.2%
45	14.3	363.8	1005	1003	0.5%	0.3%
40	12.7	323.4	1007	1005	0.7%	0.5%
30	9.5	242.6	1010	1008	1.0%	0.8%

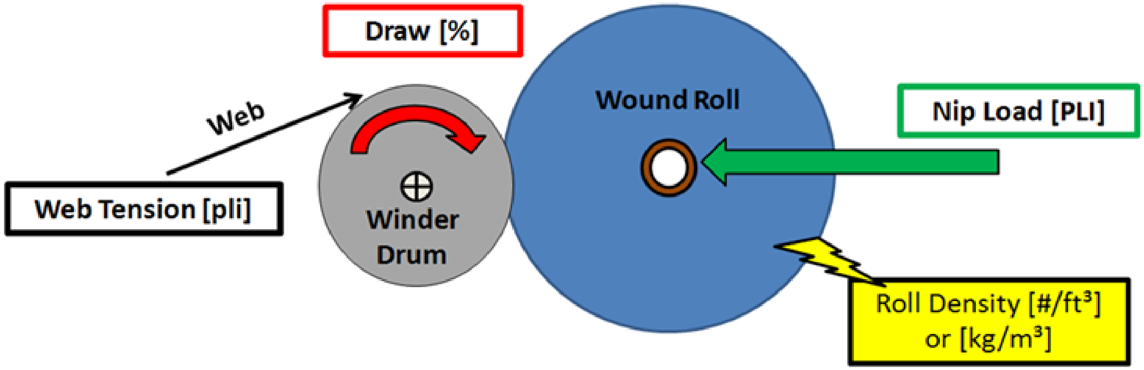


Methods to Improve Delivered Quality



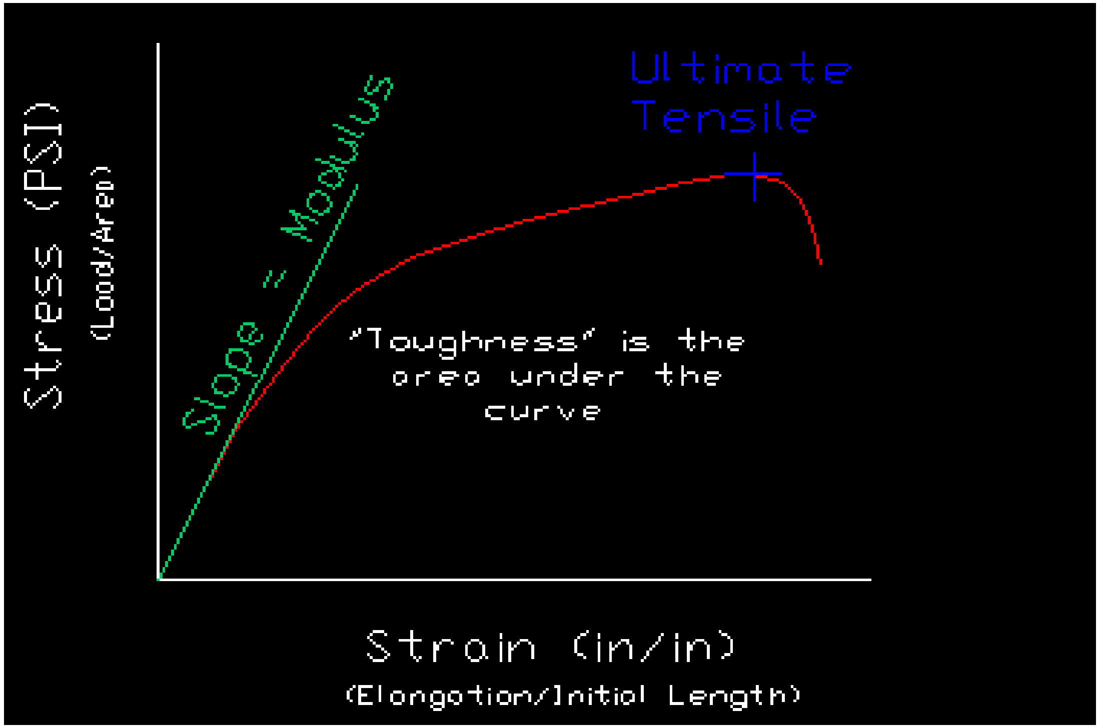
"Uhhh… Why are you looking at me?"

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

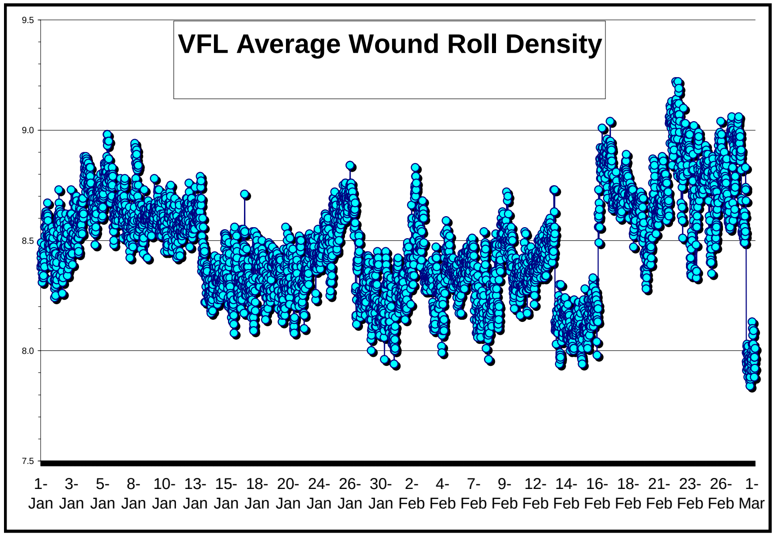
Draw versus Tension



- 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)

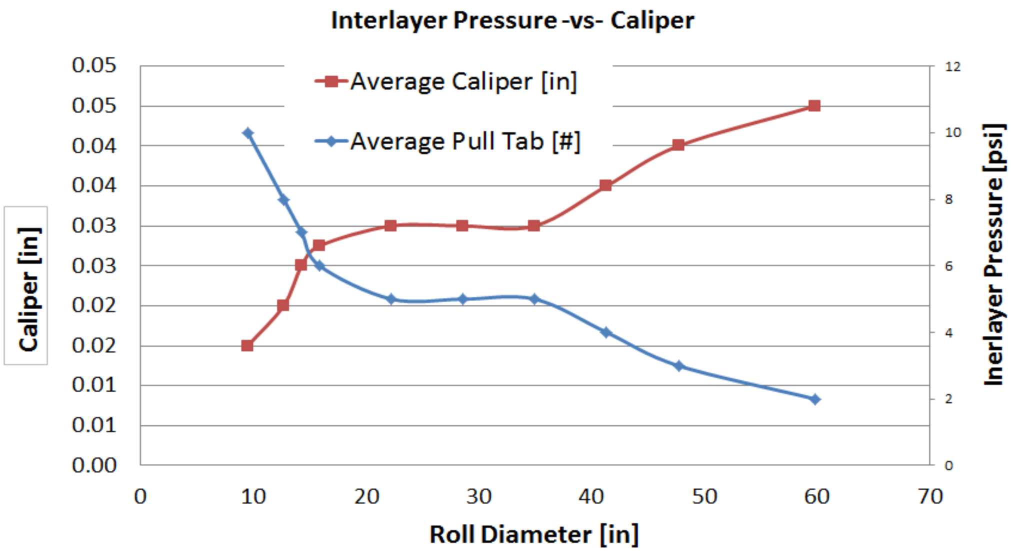
Average Wound Roll Density

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



- 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

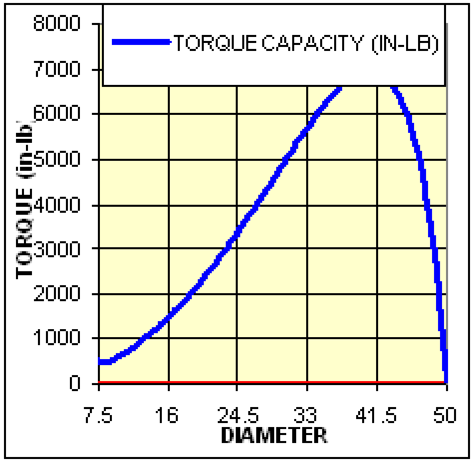
Caliper Loss



- 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

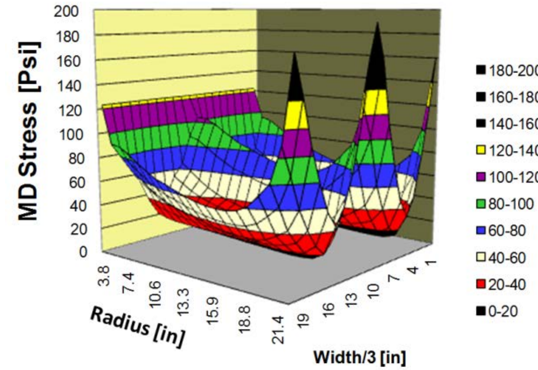
Internal Roll Slippage

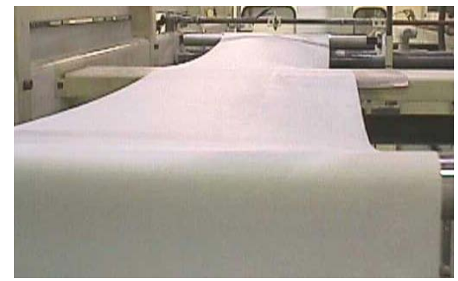
- Low torque capacity causes roll slippage
- Torque capacity is at min near the core
- Document your slip plane diameter
- Measure torque capacity using a fixture
- Document density & internal layer pressure
- Eliminate sudden changes in tension & nip
- Increase roll density
- Increase tension and/or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

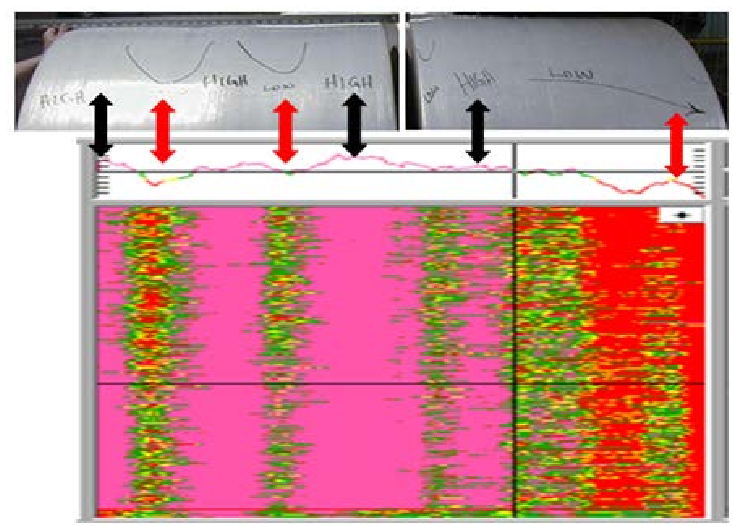


Floppy Edges

- Floppy edges, cambered webs, and baggy lanes are often the same defect
- #1 Cause: CD basis weight variation
- Others: Temp, Moisture, Forming, ect
- 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

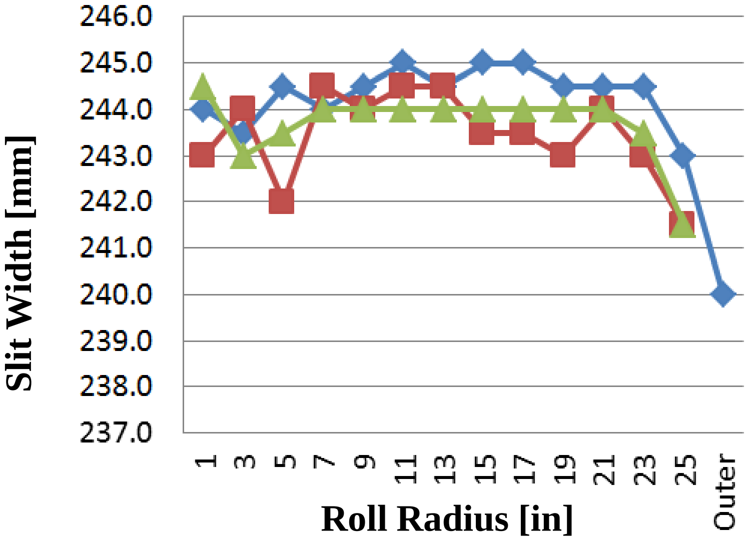


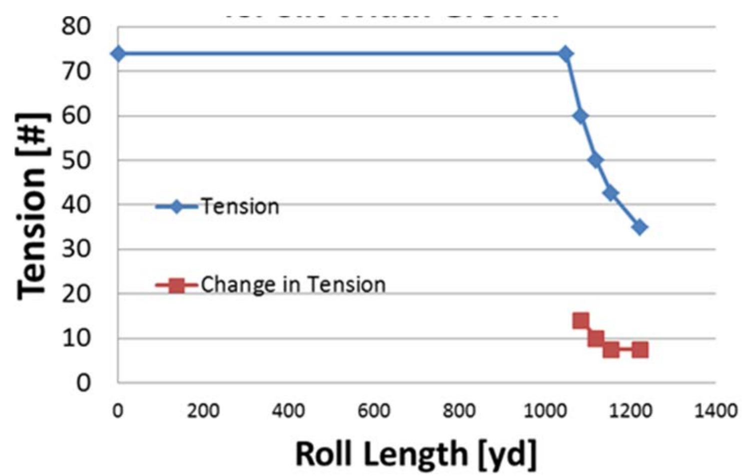




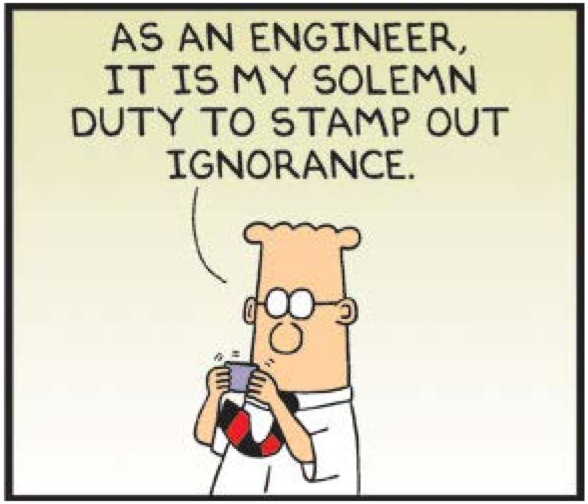
Slit Width Growth

- 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

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Questions?

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