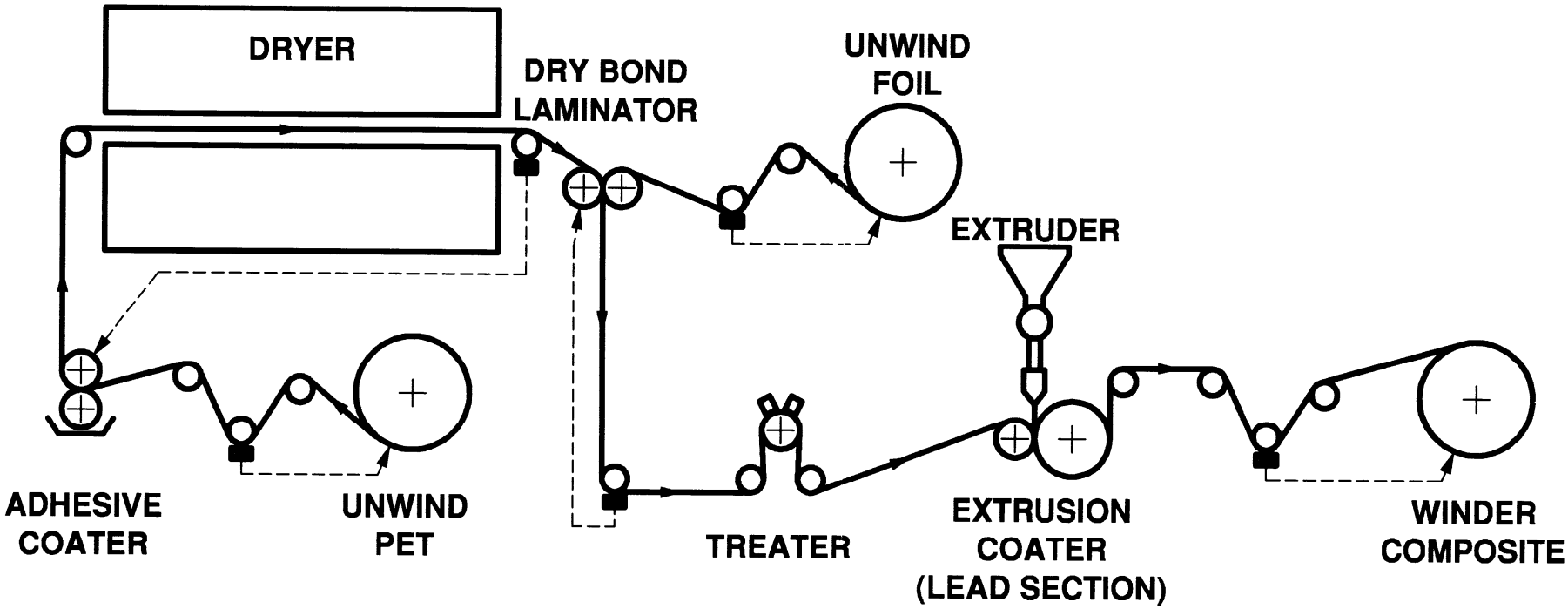
Web Handling & Winding Case Study

Based on a true Situation - Slightly Altered to Protect Confidentiality

Problem Description:

A manufacturer of the flexible packaging material used to form consumer fluid containers was have a defect called “Tunneling”

Typical Coating, Laminating and Extrusion Coating Machine Line



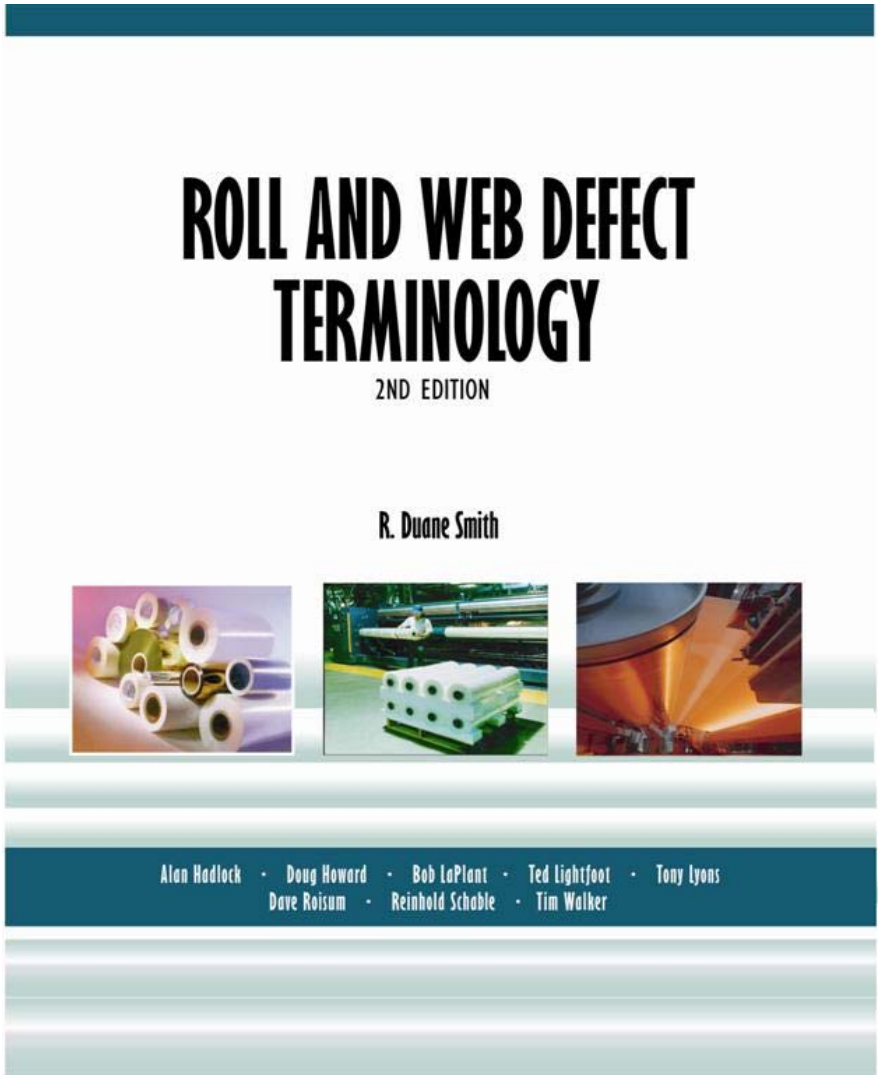
Problem Description:

Tunneling is where a small areas across the web delaminates between the PET film and the Aluminium Foil

The tunneling defect occurs after the dry bond lamination & before the PET film and aluminum foil laminate is extrusion coated with the polyethylene.

Roll and Web Defect Book

On Page # 350

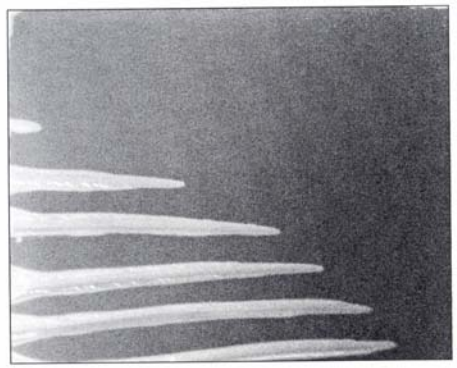


CLASSIFICATION:
- WEB DEFECTS - FILM EXTRUSION AND LAM.
- REF. NUMBER WD- FE&L -42

TD TUNNELING

SYNONYMS

ALSO KNOWN AS: FINGERS, BUCKLES, PUCKERS, TUNNELING - TRAVERSE DIRECTION.



DEFECT DESCRIPTION

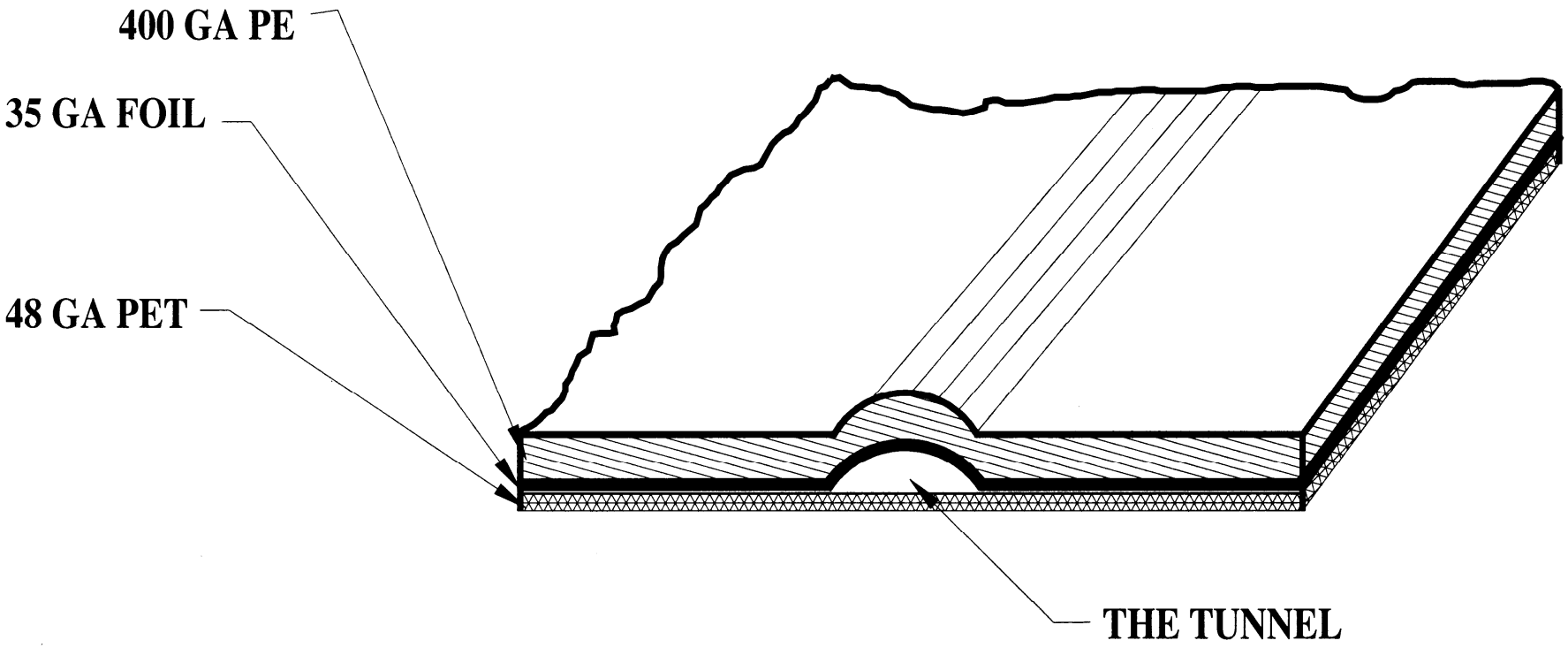
TD Tunneling: Relatively narrow buckles in one layer of a laminate which run back and forth in the transverse direction or diagonally across the sheet. They may run completely across the sheet, or only partway across.

CAUSES OF TD TUNNELING

1. TD tunnels usually occur at the laminating nip.
2. When this defect is seen at the laminating nip, the most common cause is a slack web which gathers behind the nip and passes through periodically. Because the slackness is not constant across the web, the tunnel is somewhat diagonal. The slackness can be caused by skew or a buckle lane in the film or by roll misalignment.
3. An undriven rubber roll can require excessive nip force to keep it turning. If this force is sufficient to stretch the edges of the film or compress the center, TD tunnels can form.
4. TD cockling can also cause TD tunnels if the adhesive strength is not sufficient to hold the layer flat.
5. TD tunnels that form later in the process require one layer to be under sufficient compression to overcome the adhesive force and to buckle.

Problem Description:

TUNNEL DELAMINATION



Product Structure:

Material	Caliper	Thickness %	Tensile Modulus
PET	**.00048"**	10.4%	**500,000 psi**
Foil	**.00035"**	7.6%	**10,000,000 psi**
PE	.0040"	82.0%	25,000 psi
Structure	.00483"	100%	

Product Web Width 42"

Web Tension -Films and Foil

PRODUCT	TENSION LEVELS
Polyester	0.5 to 1.5 lbs./inch/mil
Polypropylene	0.25 to 0.50 lbs./inch/mil
Polyethylene	0.25 to 0.30 lbs./inch/mil
Polystyrene	0.25 to 1.0 lbs./inch/mil
Vinyl	0.05 to 0.2 lbs./inch/mil
Aluminum Foils	0.5 to 1.5 lbs./inch/mil
Cellophane	0.5 to 1.0 lbs./inch/mil
Nylon	0.10 to 0.25 lbs./inch/mil

** From Chapter #21 of TAPPI Film Ext. Manual – 2nd edition, 2005

The Suggested Tension for each Product Used in the Laminate

Suggested Tension

PET .5-1.5 pli/mil x .48 mil x 42" **= 10-30#**

Alum Foil .5-1.5pli/mil x .35 mil x 42“ **= 7-21#**

PE .25-.3 pli/mil x 4.0 mil x 42” **= 40-48#**

Web Tensions being ran extrusion laminating process:

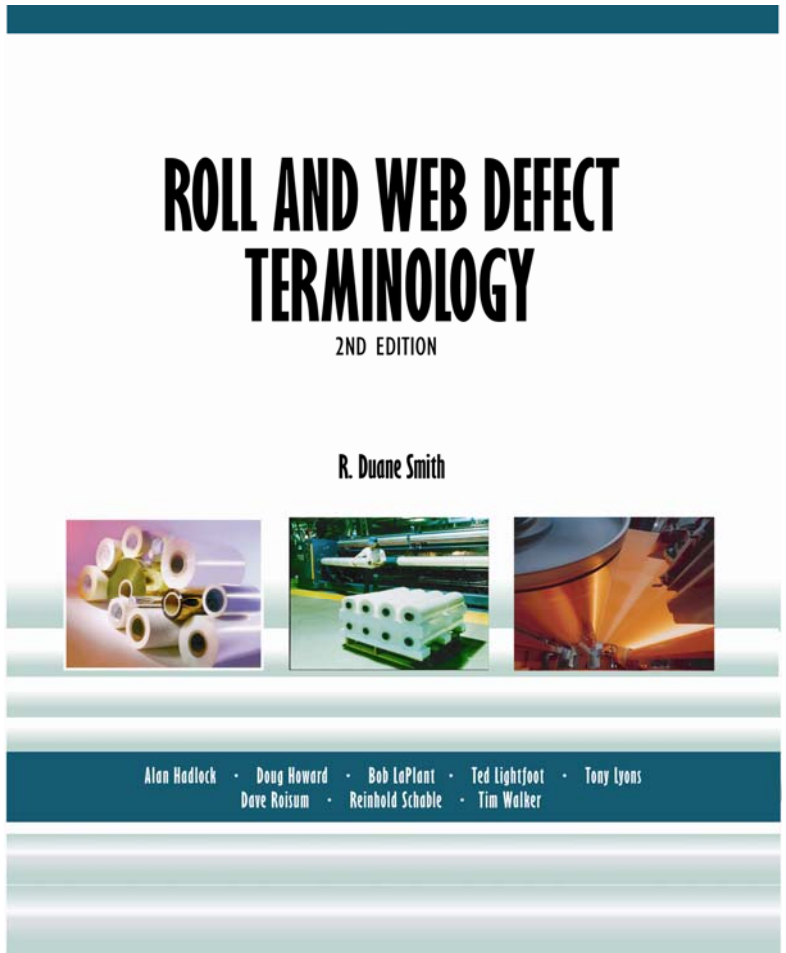
.48mil PET unwound at 30# tension

.35mil Foil unwound at 10# tension

4.8mil laminated and extrusion coated Sheet wound at 80#, constant tension

Possible Causes:

From information in the Extrusion and Laminating Chapter (#8) in the Roll and Web Defect Terminology Book:



Possible Causes:

Chapter #8- Extrusion and Laminating Defects

For a laminating process, each material should be strained by approximately the same amount before laminating to prevent defects curling and tunneling

Strain = Stress/Modulus of Elasticity (E)

= (Tension/Area)/Modulus

= Tension/(Area x Modulus)

Solution to Tunneling Problem

***Since*:** The Area x Modulus (E) (.00035 x 10,000,000) of aluminum foil is much greater than the polyester (PET) film (.00048 x 500,000).

***Then*:** For a laminating process: the **foil** should be pulled at the **high end** of the tension range and the **polyester film (PET)** should be pulled at the **low end** of the tension range.

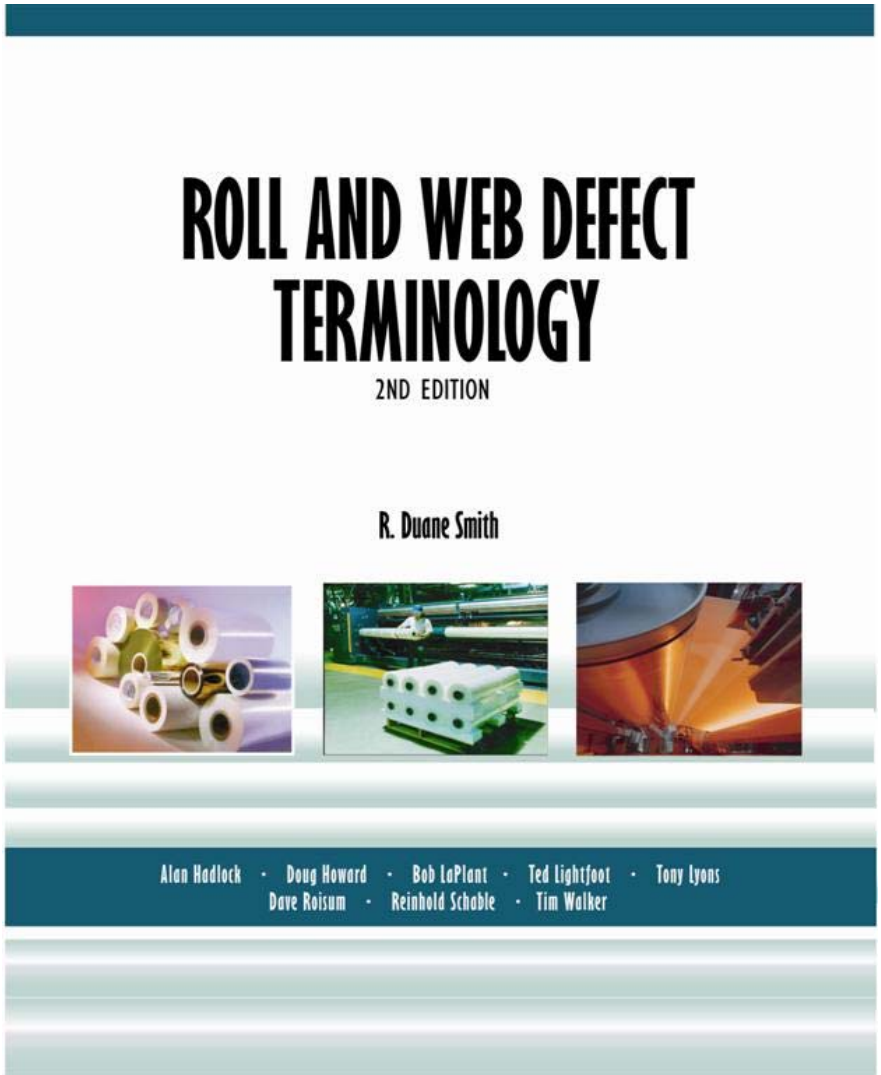
Solution to Tunneling Problem

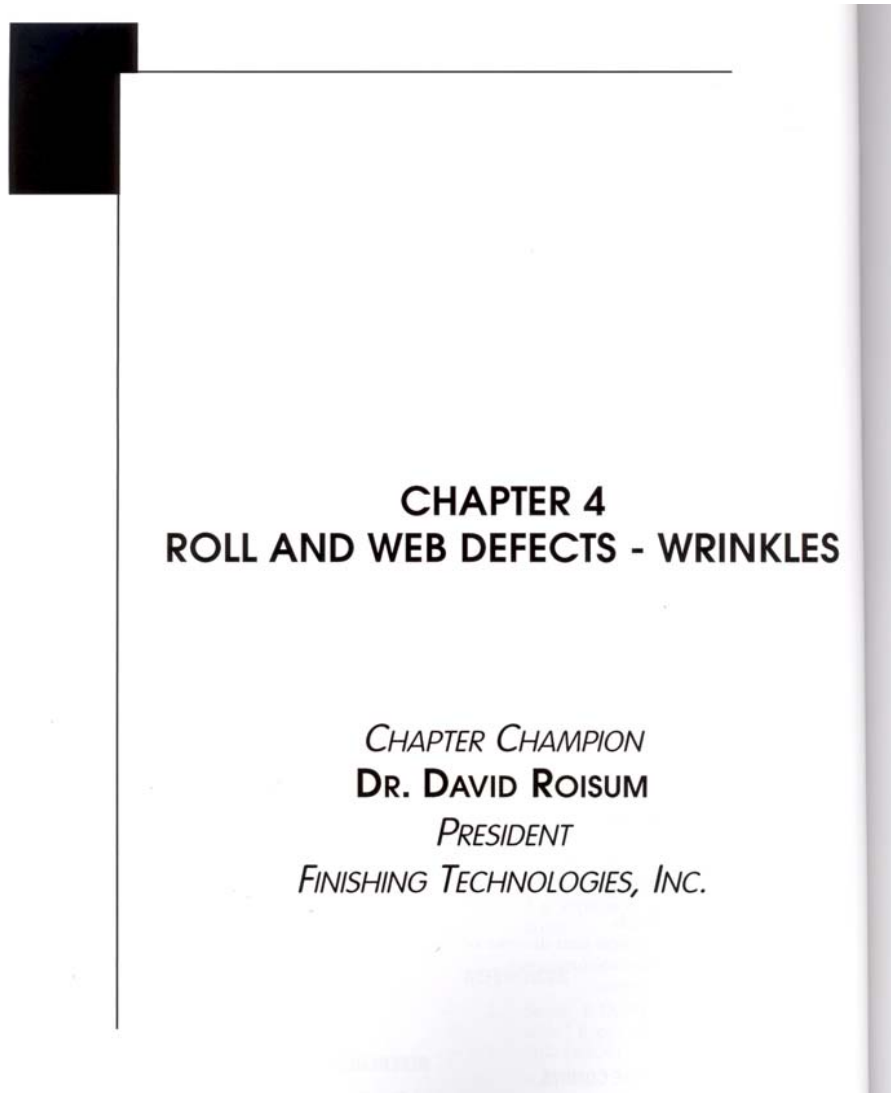
Pulling higher tension on the foil (20# vs. 10#) and lower tension on the polyester (10# vs. 30#) will eliminate the tunneling problem!

However

We still have a web handling problem! Pulling higher tension on the foil causes tension wrinkles (diagonal lightning bolt wrinkles) in the long web lead before the laminating nip.

From Dr. David Roisum's Chapter on Roll and Web Defects- Wrinkles





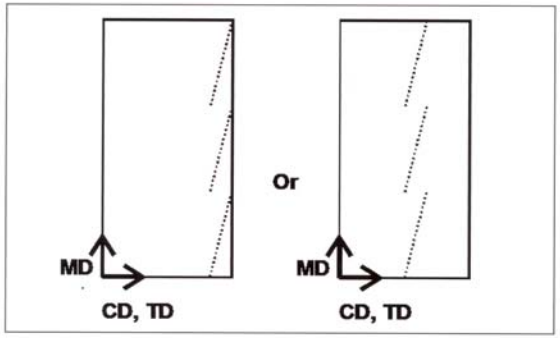
Diagonal Shear Wrinkles

on pages 150-&151

DIAGONAL SHEAR WRINKLE - ASYMMETRIC

SYNONYMS

ALSO KNOWN AS: WRINKLES - SHEAR, LIGHTNING BOLT WRINKLES.



DEFECT DESCRIPTION

Diagonal Shear Wrinkle - Asymmetric: Wrinkle(s) are oriented at an angle with respect to the machine direction. The higher the angle, the greater the shear stresses. All wrinkles point to the same side and may favor that side. Wrinkle pattern tends to be evenly spaced. Wrinkles sometimes "walk" sideways. The common mechanism for all subclasses are that something (e.g., roller or web) is "crooked."

CAUSES OF DIAGONAL SHEAR WRINKLE - ASYMMETRIC

1. Roller misalignment in the parallel (tram) direction is the most common cause. Wrinkle points to the narrow side and walks to the wide side.
2. Roller diameter variation.
3. Roller nip pressure variation.
4. Uneven pull (e.g., from narrow drive rollers, edge trim tension or direction).
5. Uneven temperature (film, foil) or moisture (paper, nylon).
6. Baggy lane or web, tight lane.
7. Gauge or other web profile variation, whether inadvertently or by design.

TAPPI - ROLL AND WEB DEFECT TERMINOLOGY

CLASSIFICATION:
- ROLL DEFECTS - WRINKLES
- REF. NUMBER WD - 4

DIAGONAL SHEAR WRINKLE - ASYMMETRIC

REMEDIES FOR DIAGONAL SHEAR WRINKLE - ASYMMETRIC

1. See above to undo the specific root cause as applicable. Work on roller quality before working on web quality if not certain of the root cause of crookedness.
2. Change tension (try both raising and lowering).
3. Use effective spreading or flattening only as a last resort.
4. Improve web uniformity and quality.

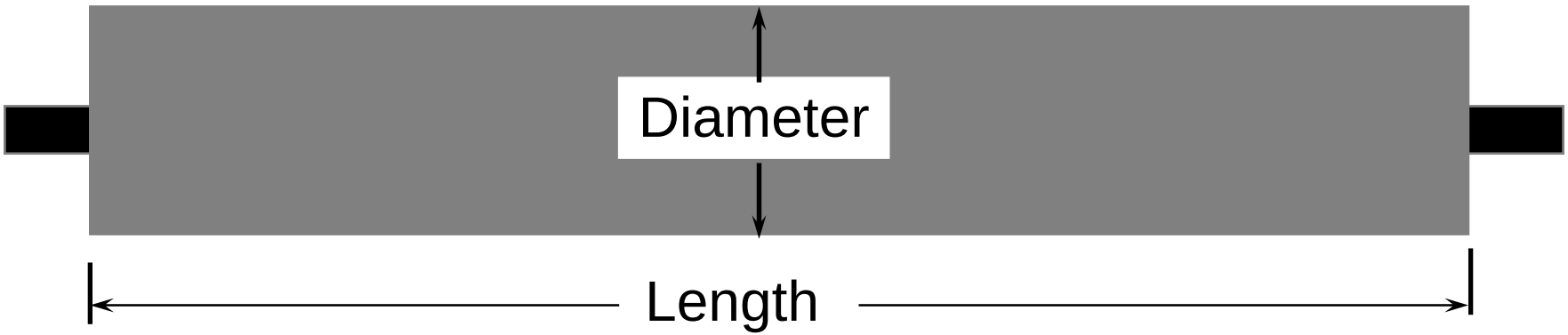
REFERENCES

1. Roisum, D.R., "What causes diagonal shear wrinkles?," *Converting Magazine* (1994).
2. Roisum, D.R., "The mechanics of wrinkles," TAPPI Journal. (1996).
3. Roisum, D.R., "The mechanics of spreading," TAPPI Journal. (1993).
4. Walker, T.J., "The signs of shear wrinkles," *Paper, Film, and Foil Converter* (2004).
5. Good, J.K., Kedl, D.M., Shelton, J.J. "Shear wrinkling in isolated spans," Proceedings, Fourth International Conference on Web Handling, June 1997:462–480.

Shear Wrinkles

Diagonal Wrinkles are tension induced wrinkles which can be caused by cross machine differences in the thickness of the web and are exaggerated by *roller deflection, roller misalignment and/or long web leads*

Unnipped Web Handling Roller DIAMETER



Roll Diameter

- **Generally** $\frac{\text{LENGTH}}{\text{DIAMETER}}$ = 16 or Less, i.e. @ 64” = 4”
- **Paperboard or Stiff Material, Consider Bend Radius**
- **Roll Deflection, *Rule of Thumb:***
  - **Generally .015” per each 100” of Roll Face**
  - **Less… If Handling Unsupported Foil**
  - **More… If Handling Extensible Web Materials**

TYPICAL TENSION VALUES-Films

FILM	**TENSION LEVELS**
• Polyester	0.5 to 1.5 lbs./inch/mil
• Polypropylene	0.25 to 0.5 lbs./inch/mil
• Polyethylene	0.1 to 0.25 lbs./inch/mil
• Polystyrene	0.5 to 1.0 lbs./inch/mil
• Vinyl	0.05 to 0.2 lbs./inch/mil
• Aluminum Foils	0.5 to 1.5 lbs./inch/mil
• Cellophane	0.5 to 1.0 lbs./inch/mil
• Nylon	0.10 to 0.25 lbs./inch/mil

1 lbs./inch/mil = 7.03 kg./cm/mm

Web Handling Roller ALIGNMENT

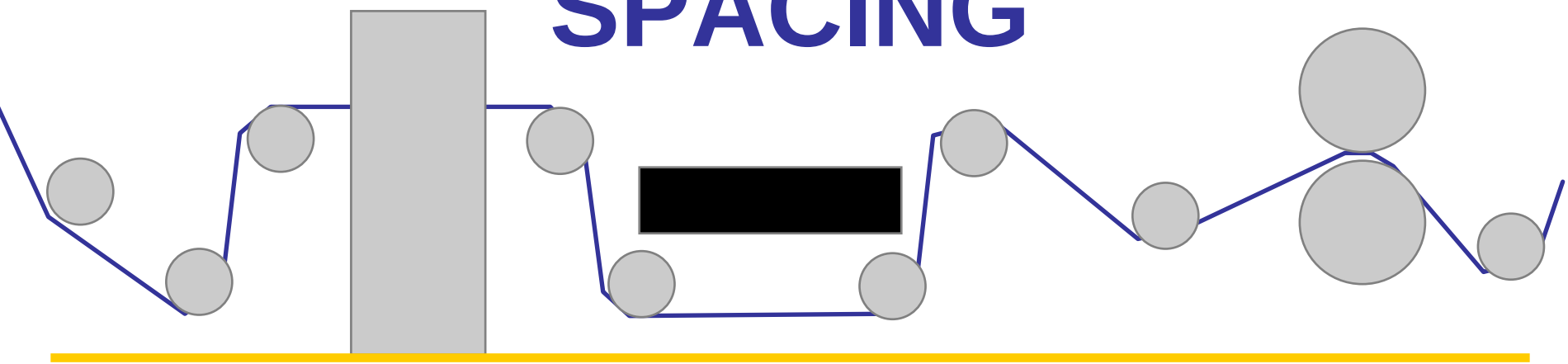
Wide Machines - Rollers Should be Level & Tram within .010”/ 100”

Narrow Machines - Rollers Should be Level & Tram within .001”/ foot

Greater Allowable Misalignment for Extensible Materials (stretchy films)

Less Allowable Misalignment for Non Extensible Materials (aluminum foil)

Web Handling Roller SPACING



"Rule of Thumb", Roll to roll spacing -2/3 Web Width

- ***Thin (.0003) Aluminum Foils*, use 24" max.**

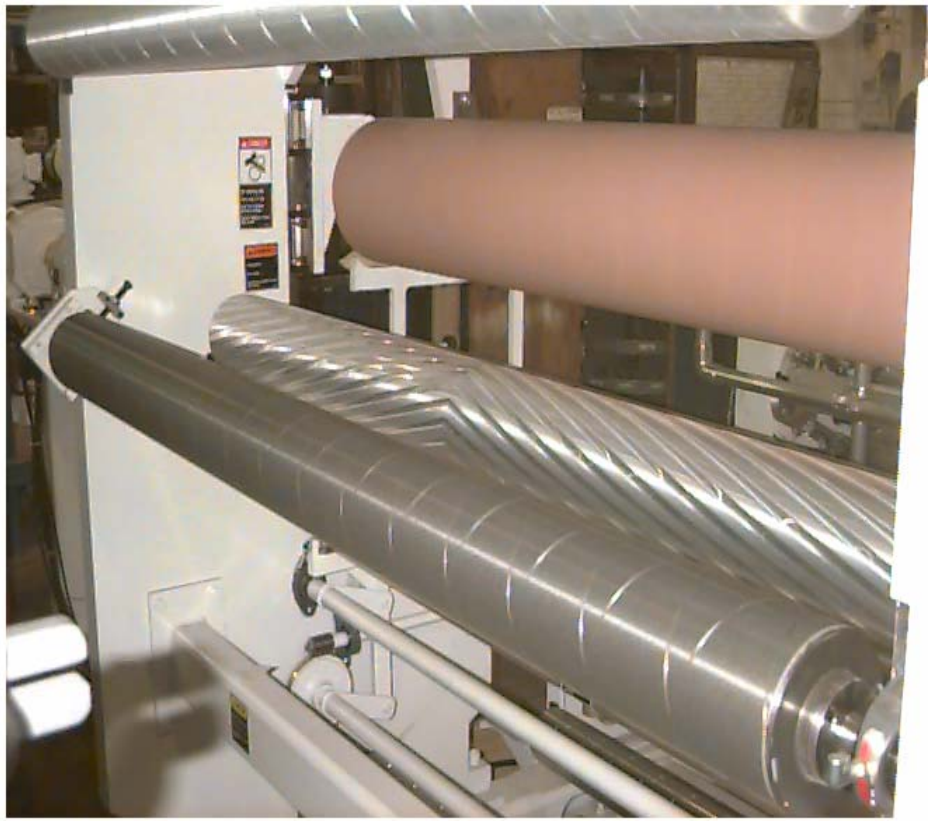
- Longer spans if a Spreader roll is used after the longer span.

To Eliminate The Foil Wrinkles

A Herringbone Spreader Roll should be added to the line just before the Foil Laminating Nip. Adding this roll will shorten the long draw and provide spreading just before laminating.

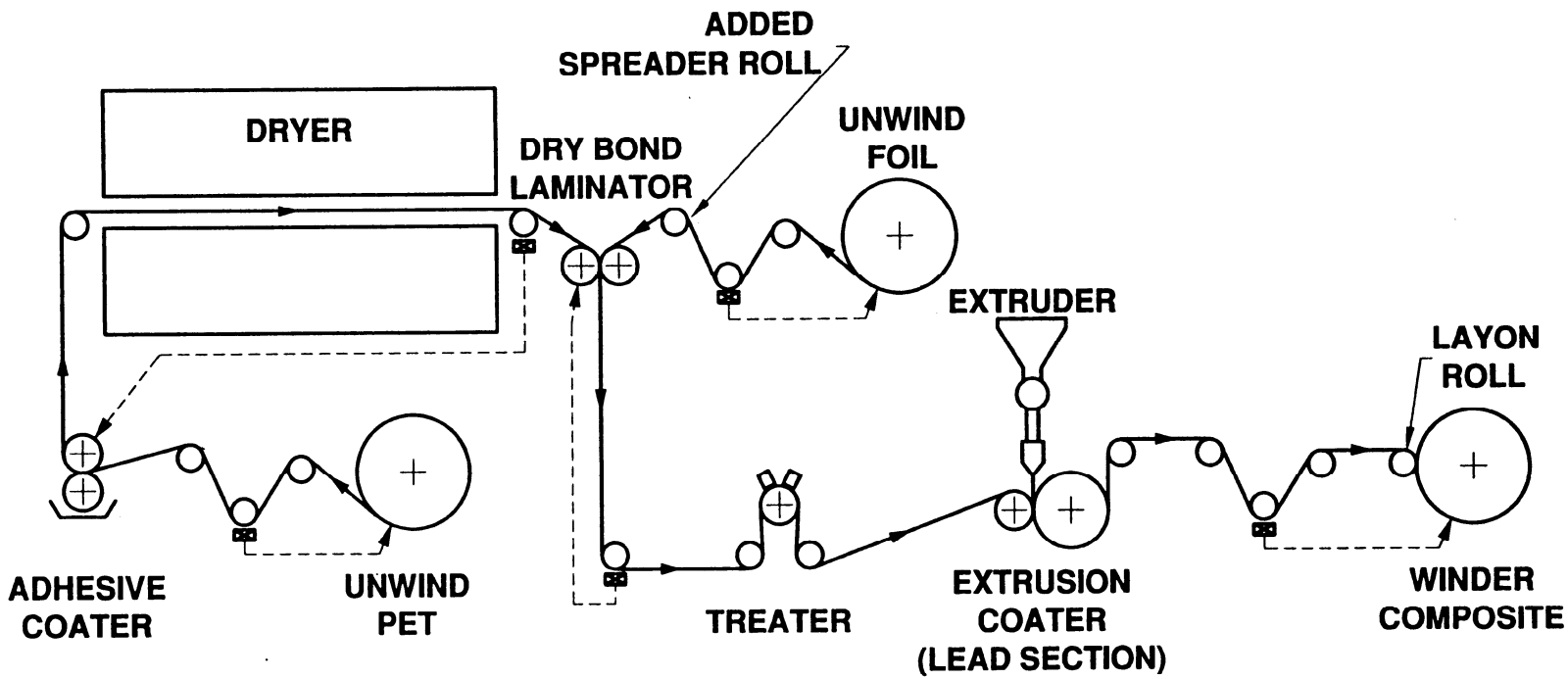
This spreader will also help compensate for possible deflection &/or alignment problems which can generate wrinkles on unsupported foil.

HERRINGBONE SPREADER ROLLS



- Outward grooves machined into shell
- Roll is directional
- Works well on foil web paths
- Keep to less than 90 degrees wrap for foil

Adding a Spreader Roll before the Laminating Nip Allowed Pulling Greater Tension Without Generating Wrinkles



Case Study in Film Ext & Laminating:

Suggested Tension

PET	.5-1.5 pli/mil x .48 mil x 42"	**= 10-30#**
Alum Foil	.5-1.5pli/mil x .35 mil x 42"	**= 7-21#**

Solution to Tunneling Problem :

Decreasing the Web Tension on the PET film from 30# to 10# and

Increasing the web tension on the foil from 10# to 20# after adding web spreading

Eliminated the tunneling problem!

Case Study in
Film Extrusion & Laminating

Questions

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Now For The Winding Problem

Case Study - **Winding**

Based on a true Situation - Slightly Altered to Protect Confidentiality

Problem Description:

This same manufacturer of the flexible packaging material used to form consumer fluid containers was having a winder defect called Buckling

Winding Problem

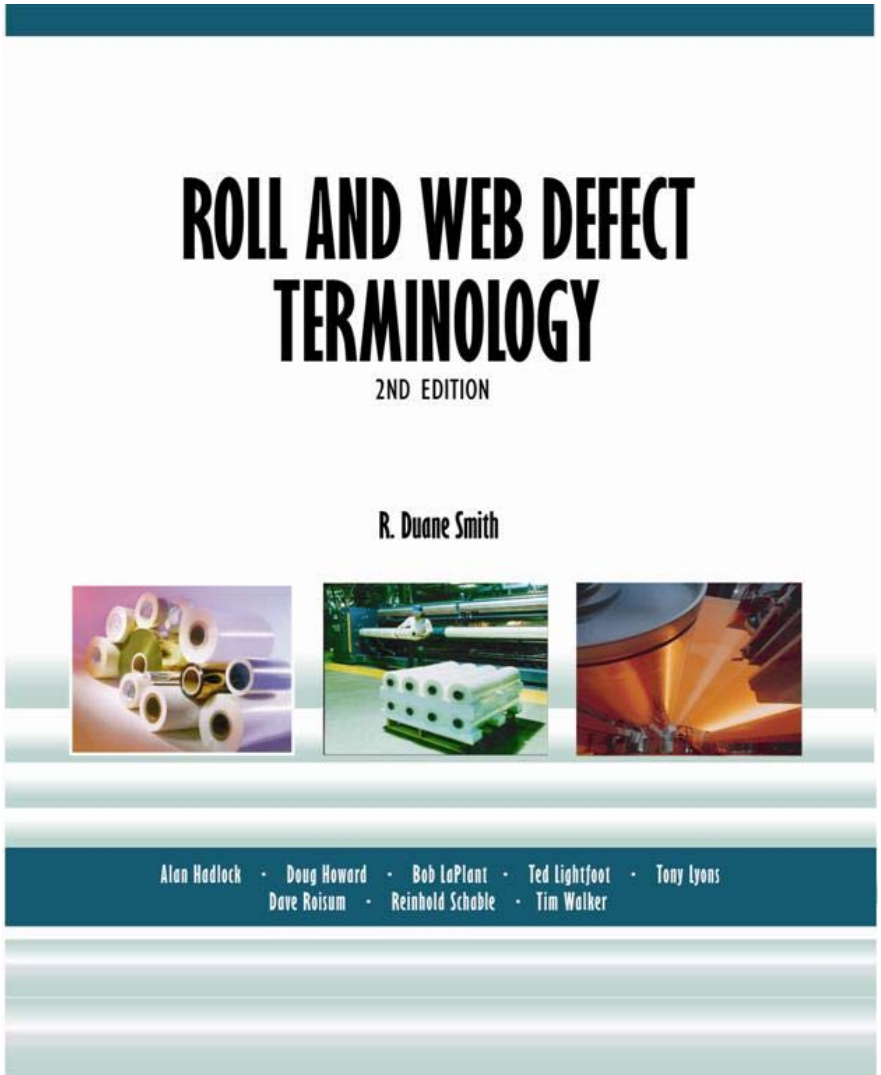
The composite structure is wound on 7" O.D. fiber cores to a diameter up to 36".

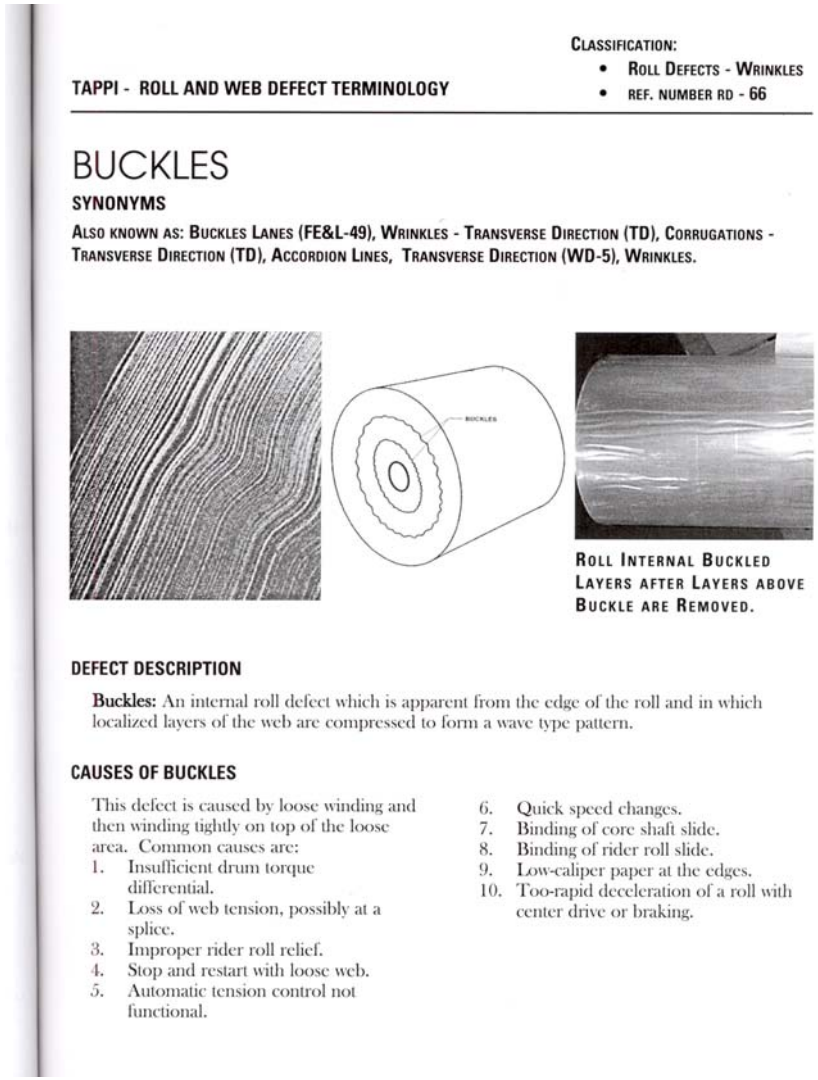
The rolls are being center wound without a nip at a constant tension of 80#.

Problem Description:

The finished rolls look excellent right off the winder however, after they have been stored for a day or longer, buckling wrinkles which cause pleat type fold overs across the web show up in the first couple inches of material wound on the core. This material must be rejected as scrap at the printing operation which cause considerable scrap costs.

In the Bible on Roll and Web Defects on Page 139





TAPPI - ROLL AND WEB DEFECT TERMINOLOGY

CLASSIFICATION:
- ROLL DEFECTS - WRINKLES
- REF. NUMBER RD - 66

BUCKLES

SYNONYMS

ALSO KNOWN AS: BUCKLES LANES (FE&L-49), WRINKLES - TRANSVERSE DIRECTION (TD), CORRUGATIONS - TRANSVERSE DIRECTION (TD), ACCORDION LINES, TRANSVERSE DIRECTION (WD-5), WRINKLES.

ROLL INTERNAL BUCKLED LAYERS AFTER LAYERS ABOVE BUCKLE ARE REMOVED.

DEFECT DESCRIPTION

Buckles: An internal roll defect which is apparent from the edge of the roll and in which localized layers of the web are compressed to form a wave type pattern.

CAUSES OF BUCKLES

This defect is caused by loose winding and then winding tightly on top of the loose area. Common causes are:

1. Insufficient drum torque differential.
2. Loss of web tension, possibly at a splice.
3. Improper rider roll relief.
4. Stop and restart with loose web.
5. Automatic tension control not functional.
6. Quick speed changes.
7. Binding of core shaft slide.
8. Binding of rider roll slide.
9. Low-caliper paper at the edges.
10. Too-rapid deceleration of a roll with center drive or braking.

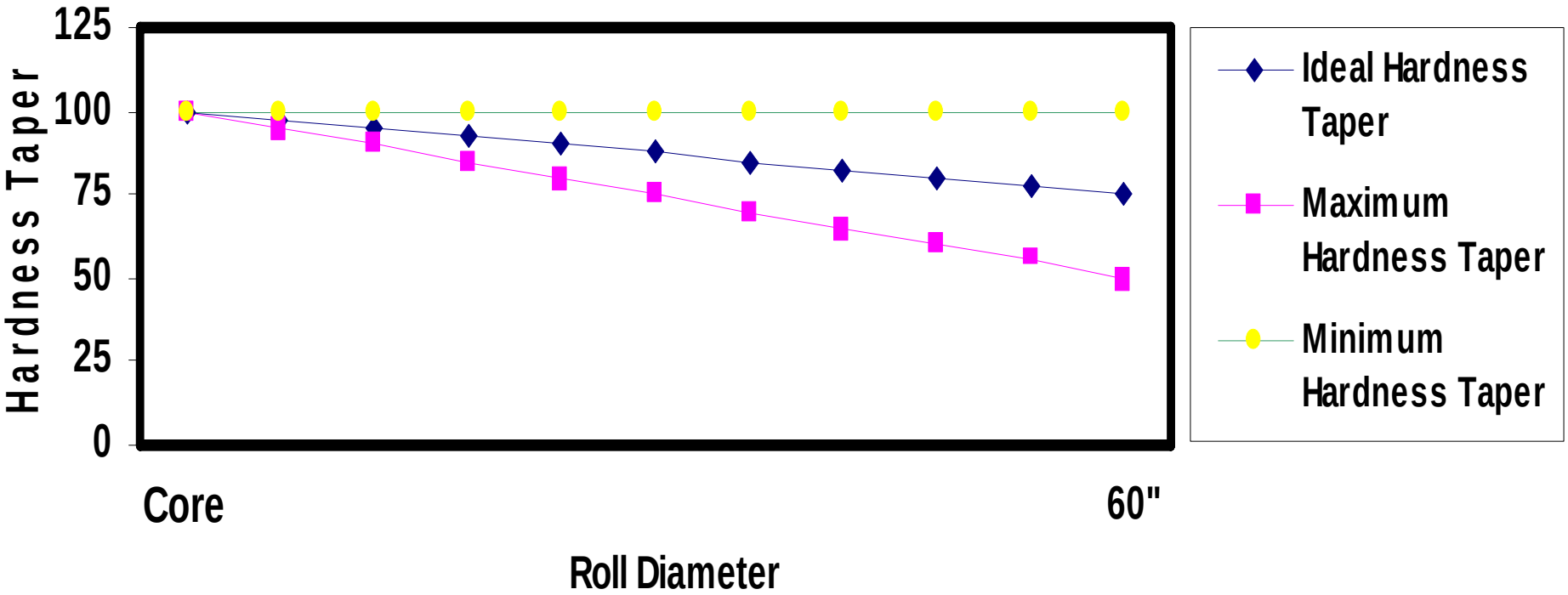
Problem Description:

- **The warm web wound into the roll is curing during storage. This causes the outer surfaces to contract and the inner wraps towards the core to be put under high compressive stresses.**
- **These high compressive stresses force any air that was wound into the roll to be compressed and/or evaluated out the sides.**
- **The web is being center wound at a constant 80# tension without using a layon roll to nip the winding roll at the point the web enters the roll.**

The Solution for Buckling Problem

This Laminated Flexible Packaging product needs to be wound with a very tight start and then taper the roll's hardness as the roll builds. Due to the cooling or curing action of the material, we would suggest a 25% to 50% winding tension taper.

ROLL HARDNESS PROFILE



** From Chapter #21 of TAPPI Film Ext. Manual – 2nd edition, 2005

T.N.T. - Tension Principle of Winding

Common Practice is to start winding with 50% greater tension then the unwinding tension.

(See chart on Typical Tension Values-Paper suggesting unwinding at .035 x basis weight and winding at .055 x basis weight.)

Suggested TENSION VALUES**-

Paper

PAPER, Basis Wgt.	TENSION LEVELS
15 lbs./ream (3000 sq.ft.)	0.5 pli
20 lbs./ream	0.75 pli
30 lbs./ream	1.0 pli
40 lbs./ream	1.5 pli
60 lbs./ream	2.0 pli
80 lbs./ream	2.5 pli

Unwinding Tension (pli) = paper basis weight x 0.035

Winding Tension (pli) = paper basis weight x 0.055

Conversion Factors lbs./3000 ft^2 x 1.63 = = grams/sq. meter

pli x 5.6 = kg/cm

**** From Chapter #21 of TAPPI Film Ext. Manual – 2nd edition, 2005**

The Suggested Tension for each Product Used in the Laminate

Material	Tension/Mil	x	Thickness	x	Width	=	***Suggested Tension***
PET	.5-1.5 pli/mil	x	.48 mil	x	42"	=	**10-30#**
Alum Foil	.5-1.5pli/mil	x	.35 mil	x	42	=	**7-21#**
PE	.25-.3 pli/mil	x	4.0 mil	x	42“	=	**40-48#**

Total Tension = 57# to 99#

Tension Principles of Winding**

Taper Tension

Reduce the tension smoothly as the roll diameter increases:

0 - 50% taper, 25% common

Taper Tension reduces - telescoping, end crowning, starring and buckling problems

**** From Chapter #21 of TAPPI Film Ext. Manual – 2nd edition, 2005**

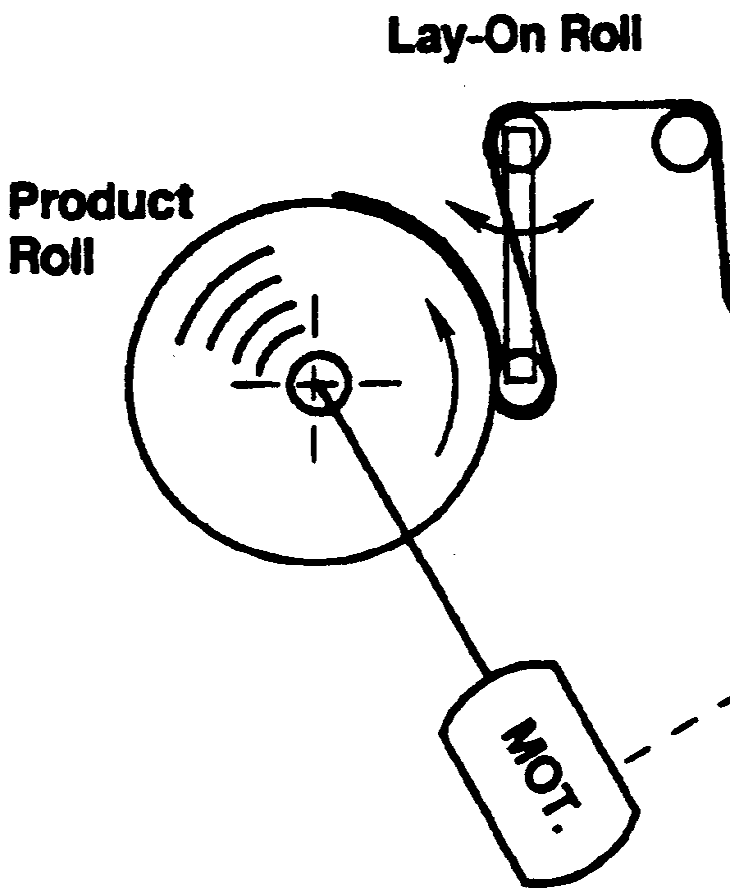
T.N.T. - Tension Principle of Winding

To obtain the req'd. tight start, it is suggested that winding tension at the start be about 100#.

(10# PET, 20# foil and 40# for the PE = 70# plus 50% greater starting tension = approx. 100#)

Then tapering the winding tension to 50# (50% taper) at a 36" diameter.

Nip Principles of Winding**



- Nip Load should be tapered as roll winds to prevent starring and telescoping. However,
- Larger winding roll's dia. drags more air and produces a Nip Taper Loading with a constant loading pressure.

** From Chapter #21 of TAPPI Film Ext. Manual – 2nd edition, 2005

T.N.T. -Nip Principle of Winding

This application AIR is NOT our Friend!

Should use the nip from a lay-on roll to build the desired roll hardness and to minimize air wound into the roll.

Another *Rule of Thumb-*

Suggested starting nip is 3 times the starting tension or

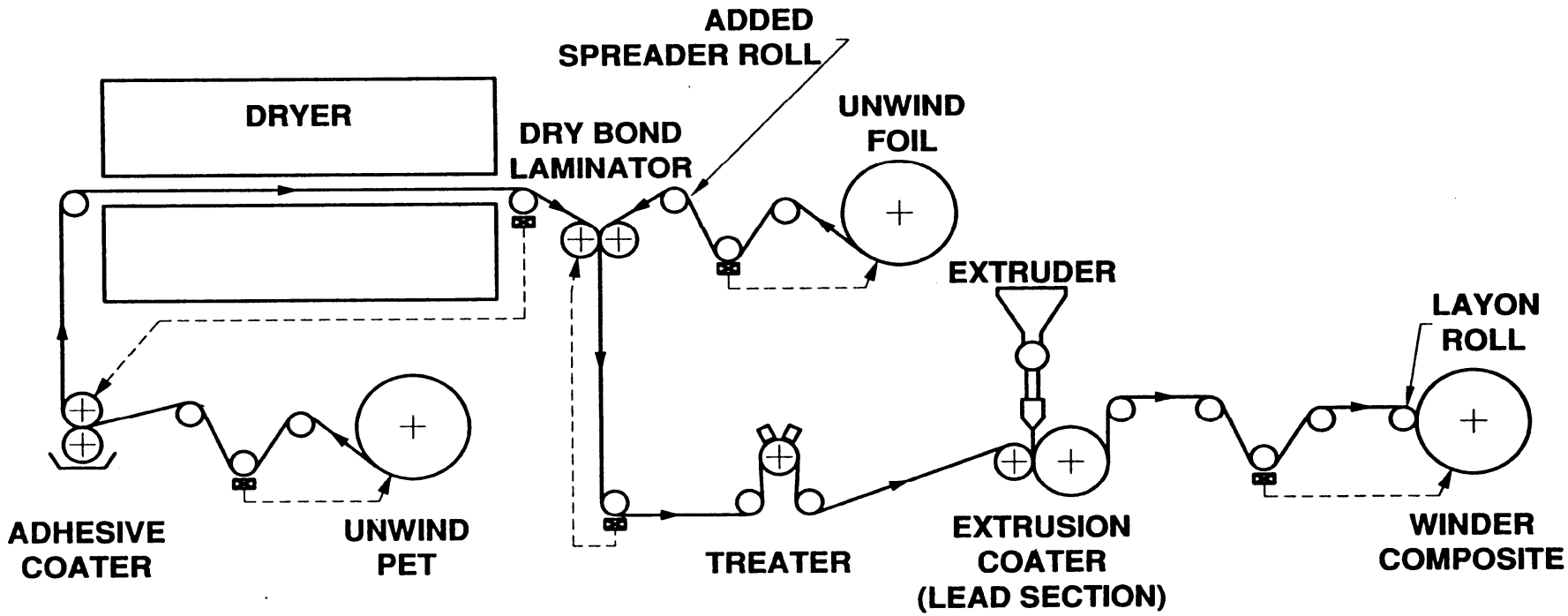
3 x 100# =300#.

T.N.T. -Nip Principle of Winding

This nip load can be held constant as the hydraulic pressure of the air reduces the nip due to the amount of air being brought into the nip as the winding roll's diameter builds.

If greater roll hardness taper is desired, then the nip load can be decreased as the winding roll's diameter builds to further decrease the inwound tension as the roll winds.

Lay-on Nip Roll Added to the Winder – To remove air from the winding roll.



The Solution for Buckling Problem

By increasing the Winding Tension to a 100# at the start and then tapering to 50# at a 36" diameter.

Then by adding a nip roll which was used to supply a 300# Constant Nip to evacuate the air.

The Buckling Problem as the roll cured was eliminated!

Case Study in Winding Defect - Buckling

Questions

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Thank You!!!

TAPPI

2010 PLACE Extrusion Coating

Short Course

Challenges of

WEB HANDLING AND WINDING

R. Duane Smith

Black Clawson Converting Machinery / D-S LLC