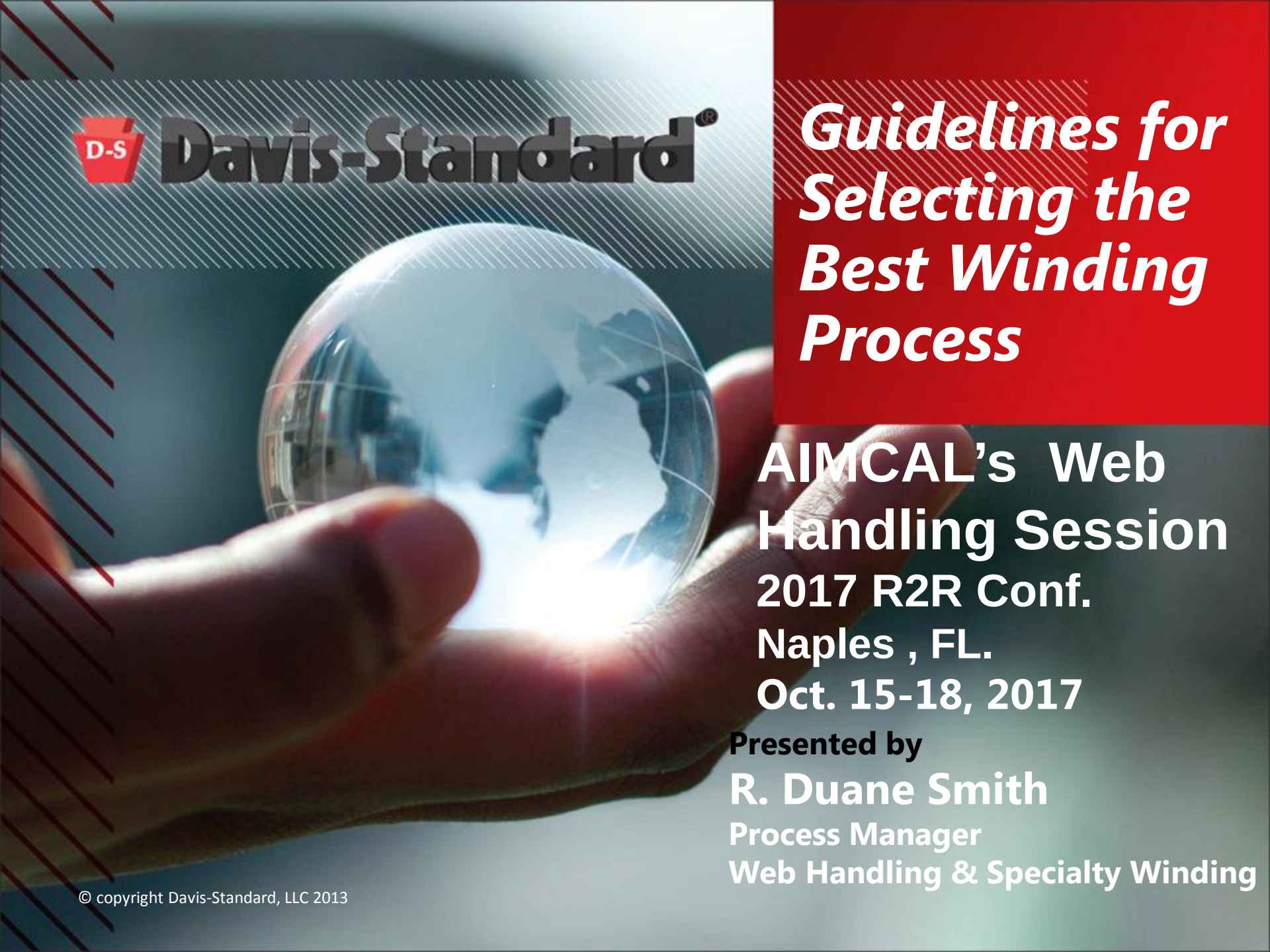


Guidelines for Selecting the Best Winding Process

AIMCAL's Web Handling Session

2017 R2R Conf.
Naples , FL.
Oct. 15-18, 2017

Presented by
R. Duane Smith
Process Manager
Web Handling & Specialty Winding

There is a lot of Science that goes into Winding

The Winding Principles are well established and have been proven and modeled at the Web Handling Research Center at Oklahoma State University*

*Stillwater, Oklahoma, USA

The Art of Winding

Yet determining which of these principles or the proportional amount of each to use for proper winding of different materials under different conditions is still considered an Art

This presentation will discuss:

- *The Importance of Roll Hardness*
- *Winding Principles used to develop roll hardness.*
- *How these are used on different types of winders.*
- *Present the Product Parameters that each type of winder is best suited for.*

Goal of the Presentation-

To assist in determining the best type of winder to use for consistently producing quality, defect free rolls of your web materials.

The Importance of Roll Hardness

Roll Hardness is the Critical Factor in Determining the Difference Between A Good Roll & a Poor Quality Roll.

Secret to building a Good Structure

Start on a a good solid foundation.
Then wind with progressively softer roll hardness.

Proven Fact:

As a roll winds - Inwound tension or residual stresses build up inside the roll.

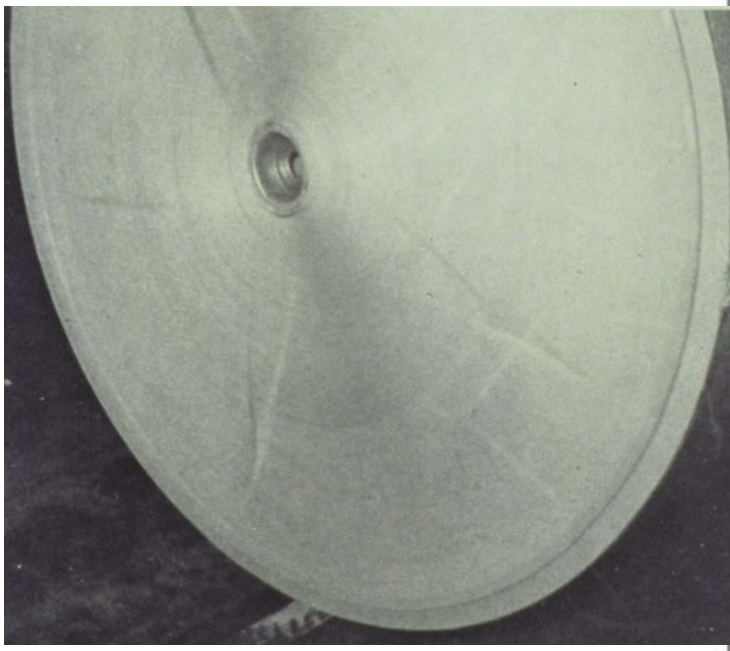
If stresses become greater as roll winds larger - inner wraps towards the core will loosen & may even go into compression.

This causes rolls to contain defects such as telescoping, buckling and/or starring.

Paper and Nonwoven Defects

Telescoping

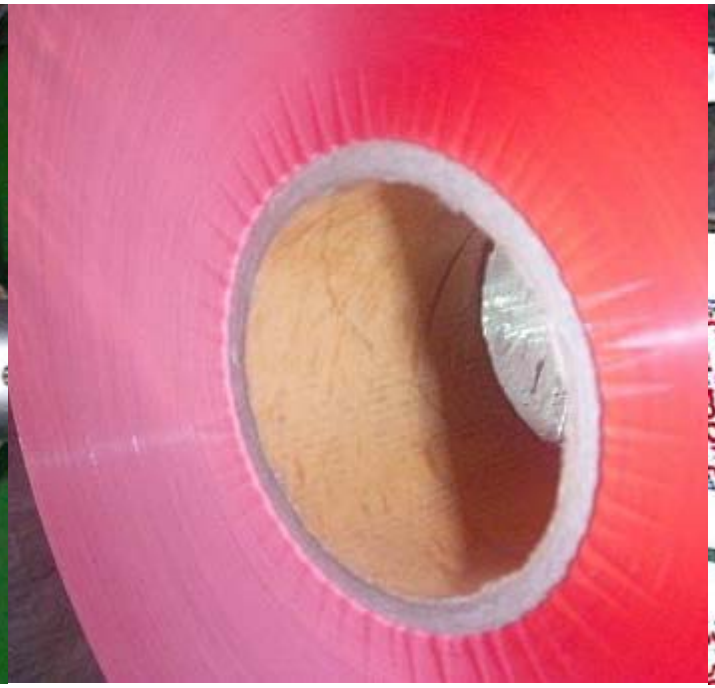
Buckling



Starring Defects

Film Roll Defects

Telescoping

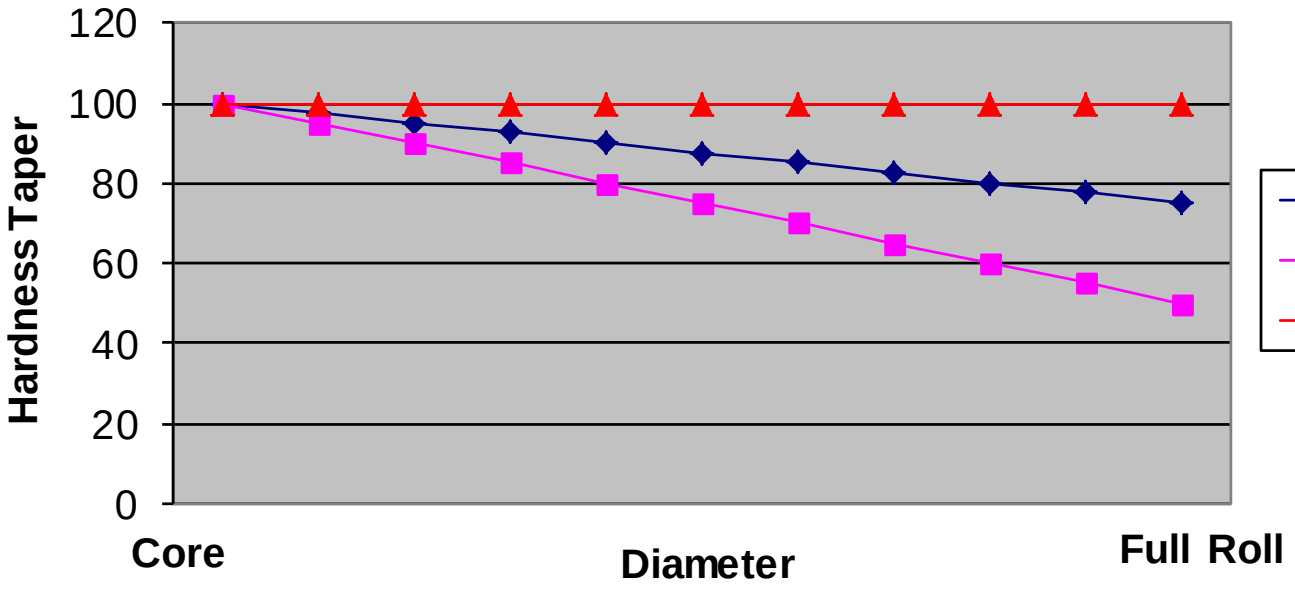


Buckling

Starring Defects

ROLL HARDNESS MUST BE PROFILED TO PREVENT THESE!

Roll Hardness Taper Curves



Normally straight line profiles are used. However, today's control systems allow profiling the roll hardness tools to provide non-linear hardness tapers if required.

Winding Principles used to develop roll hardness.

THREE BASIC PRINCIPLES TO CONSISTENTLY WIND DYNAMITE ROLLS ARE T.N.T.

T*ension* - The Winding Web's ***T***ension

N*ip* - The ***N***ip of the Pressure Roll or Drum

T*orque* - The ***T***orque from the Center Drive or Torque Drum

Winding Principles verses Material Characteristics

Low Modulus (stretchy) Materials-

***T*ension is the dominant principle**

High Modulus (stiff) Materials-

***N*ip and *T*orque are the dominant principles.**

Web Tension-
How much Tension should you use?

Pull sufficient tension to convey imperfect web materials straight through the process without wrinkles

Web Tension = Strain (stretch) put into the web

Function (Mat'l. Modulus, Width, Thickness)

Strain = Stress/Modulus of Elasticity (E)

= (Web Tension/Area)/Modulus

= Web Tension/(Width x Thickness)/Modulus

Suggested amounts of web tension

- *Rule of Thumb* is 10 – 20 percent of machine direction elastic limit (yield strength) of the web material

Typical Tension Values – Paper, Films & Foil

Films	Tension Levels
• Paper Products	0.35 to 0.55 lbs./inch/mil
• Polyester	0.5 to 1.5 lbs./inch/mil
• Polypropylene	0.25 to 0.5 lbs./inch/mil
• Polyethylene	0.10 to 0.25 lbs./inch/mil
• Polystyrene	0.25 to 1.0 lbs./inch/mil
• Vinyl	0.05 to 0.2 lbs./inch/mil
• Cellophane	0.5 to 1.0 lbs./inch/mil
• Nylon	0.10 to 0.25 lbs./inch/mil
• Aluminum foils	0.5 to 1.5 lbs./inch/mil

Conversion Factor - 1 lbs./inch/mil = 7.03 kg./cm/mm

Tech Tip - Web Tension

For a copy-

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TECH TIPS

The Global Advantage™

HELPING YOU GET MORE OUT OF YOUR PRODUCTION LINE

Guidelines for Web Conveyance and Winding Tensions

Web handling can be a real challenge! We need to convey a web flat and straight through the process without generating defects such as wrinkles. To do this, we need to convey this web under a certain amount of web tension. The question then becomes, "How much web tension do I need to ensure success in producing a defect-free web product that will run problem-free on our customer's process and meet the expectations of their Customer for the web material?" The answer to the web conveyance question, "How much web tension should I use?" : AS LITTLE AS POSSIBLE!

In a perfect world, we would not need to use web tension. We would simply float the sheet straight through the process without wrinkling or bagginess defects. Unfortunately, webs are not perfect and rollers are not perfect. Therefore, we do need to use web tension to successfully convey webs through a production line. This Tech Tip will address the suggested maximum web tension. Just remember, in almost all cases, when it comes to web tension – MORE is usually NOT BETTER!

Since no web is perfectly flat, we need to convey imperfect webs. The suggested amount of web tension is typically between 10 and 25 percent of the web material's tensile strength or elastic limit when dealing with stretchy materials For example, if it takes 100 newtons (23 lbs.) of tension to stretch a 2.5 cm (1 inch) web to the point it will break or permanently deform, then the suggested amount of web tension to convey this web would be 10 percent of this number or 10N/2.5cm = 4 newtons/cm (2.3 pli) of tension with a maximum tension of 10 newtons/cm (5.7 pli) = 25 percent of the elastic limit.

Plastic and paper technical organizations such as SPE and TAPPI have done studies and gathered a great deal of empirical data on the suggested amount of tension. They suggest that the MAXIMUM web tension for plastic films is below the level that the film is stressed to 1.5 percent of the modulus of elasticity of the film material.

Typical Tension Values

Films and Foil

Films	Tension Levels
Polyester	0.5 to 1.5 lbs./inch/mil
Polypropylene	0.25 to 0.5 lbs./inch/mil
BOPP	0.25 to 1.0 lbs./inch/mil
Polyethylene	0.10 to 0.3 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	0.1 to 0.25 lbs./inch/mil

Figure 1

For the paper and paperboard industry, TAPPI suggests from their empirical studies that the maximum web tension be determined by multiplying the paper's basis weight (#/3000 square feet) by a factor of .035. Therefore, a 15# paper x .035 = 0.5 pli tension, a 30# paper x .035 = 1.0 pli, and a 60# paper x .035 = 2 pli maximum web tension. Figure 2 is a table of the suggested maximum tensions for papers.

Typical 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) = basis weight X 0.035	
Winding Tension (pli) = paper basis weight X 0.055	
0.035 X 1.5 (50% greater) = Approx. 0.055	

Figure 2

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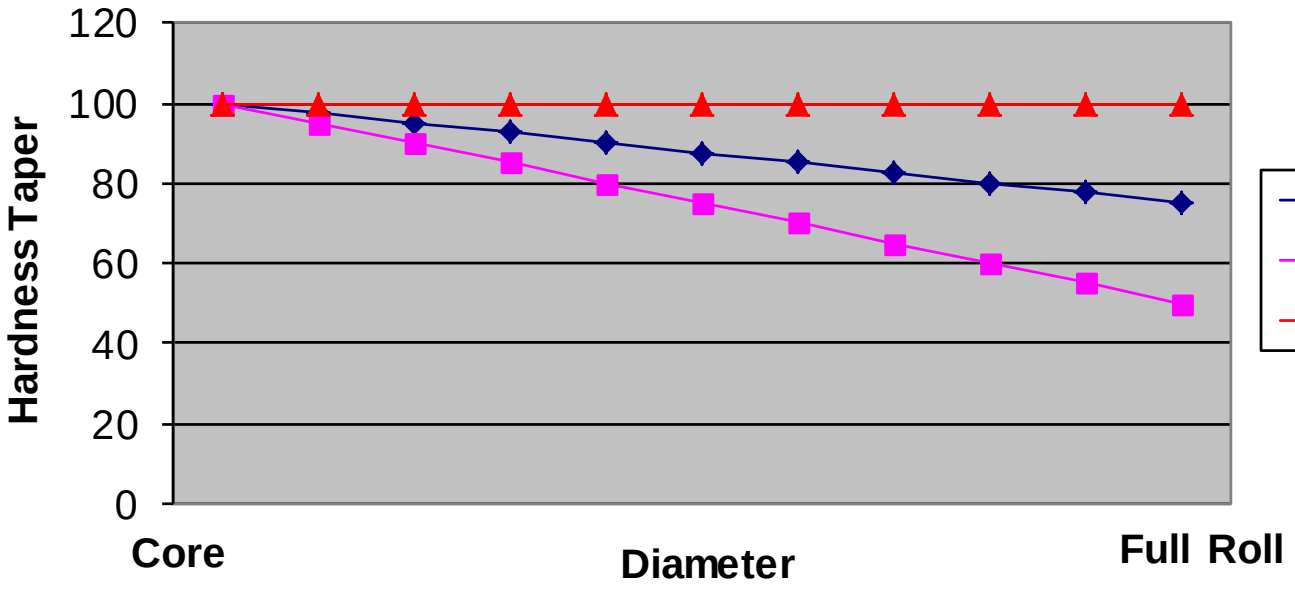
Tension Principles of Winding

Taper Tension

- **Reduce the tension smoothly as the roll diameter increases**
- **Suggested Winding Taper is 25 - 50%**

Remember this slide?



NIP Principle of TNT Winding

Inelastic (non stretchy) webs

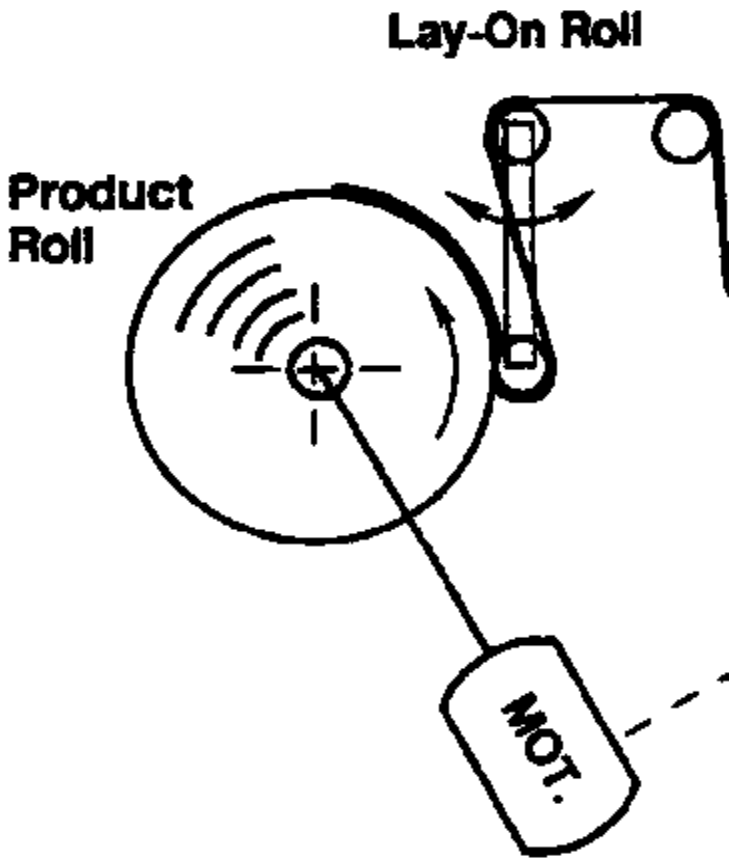
- ***N***ip tension is dominant principle of winding in order to control roll hardness

Nip of winding rolls

- **Removes the boundary layer of air following the web**
- **Adds inwound tension - the higher the nip, the harder the rolls**

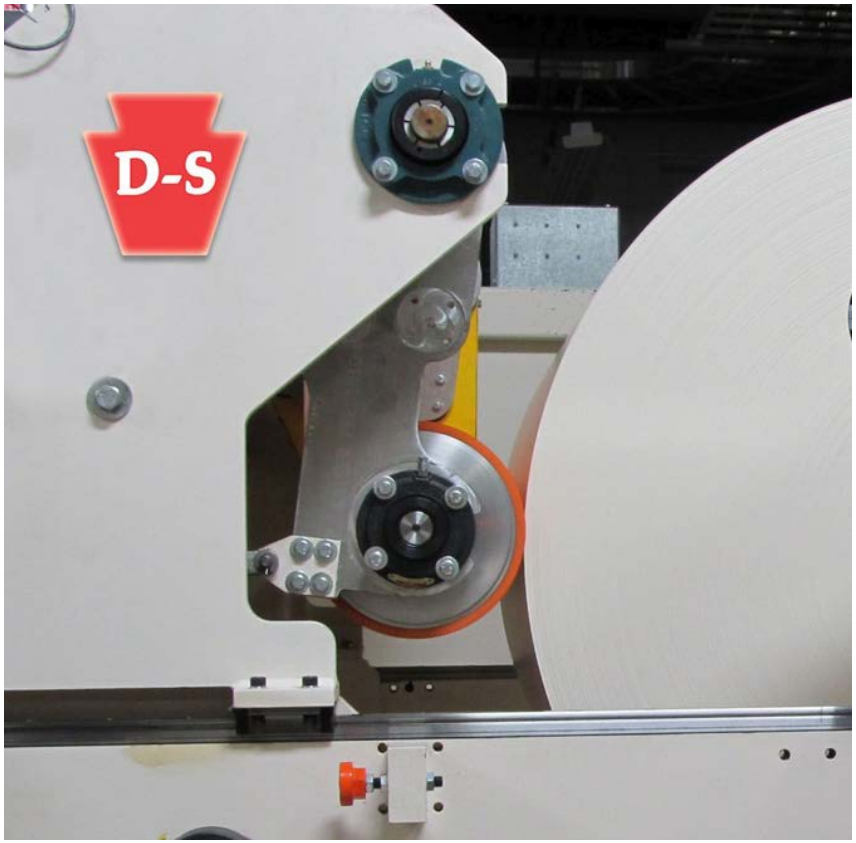
Challenge is to have sufficient nip to wind hard and straight rolls without winding in too much inwound tension to prevent blocking and deforming the web over caliper bands

NIP Principle
Important Considerations



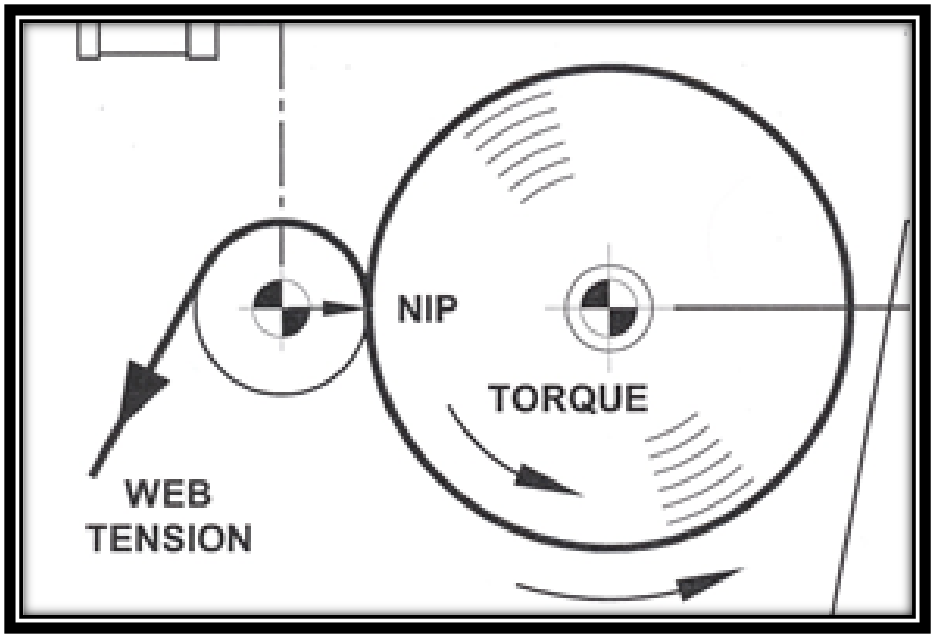
- Nip must be applied where web enters the winding roll
- The winding roll's and lay-on roll's weight and web tension should not affect the nip loading

NIP Principle
Important Considerations



- **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 larger footprint for Tapered Loading Pressure with a constant loading force.**

TORQUE Principle of TNT Winding



- **Torque cinches the inner layers while winding**
- **Torque produces Web Tension when Center Winding**
- **Torque Independent from Web Tension when C/S Winding**

TORQUE Principle of TNT Winding
When Center/Surface Winding

Typically, when Center/Surface winding Torque produces a winding tension starts 25-50% greater than the incoming web tension and then this winding tension is tapered as the roll builds in diameter to a value at or even less than the incoming web tension.

How Winding Principles are used on different types of winders.

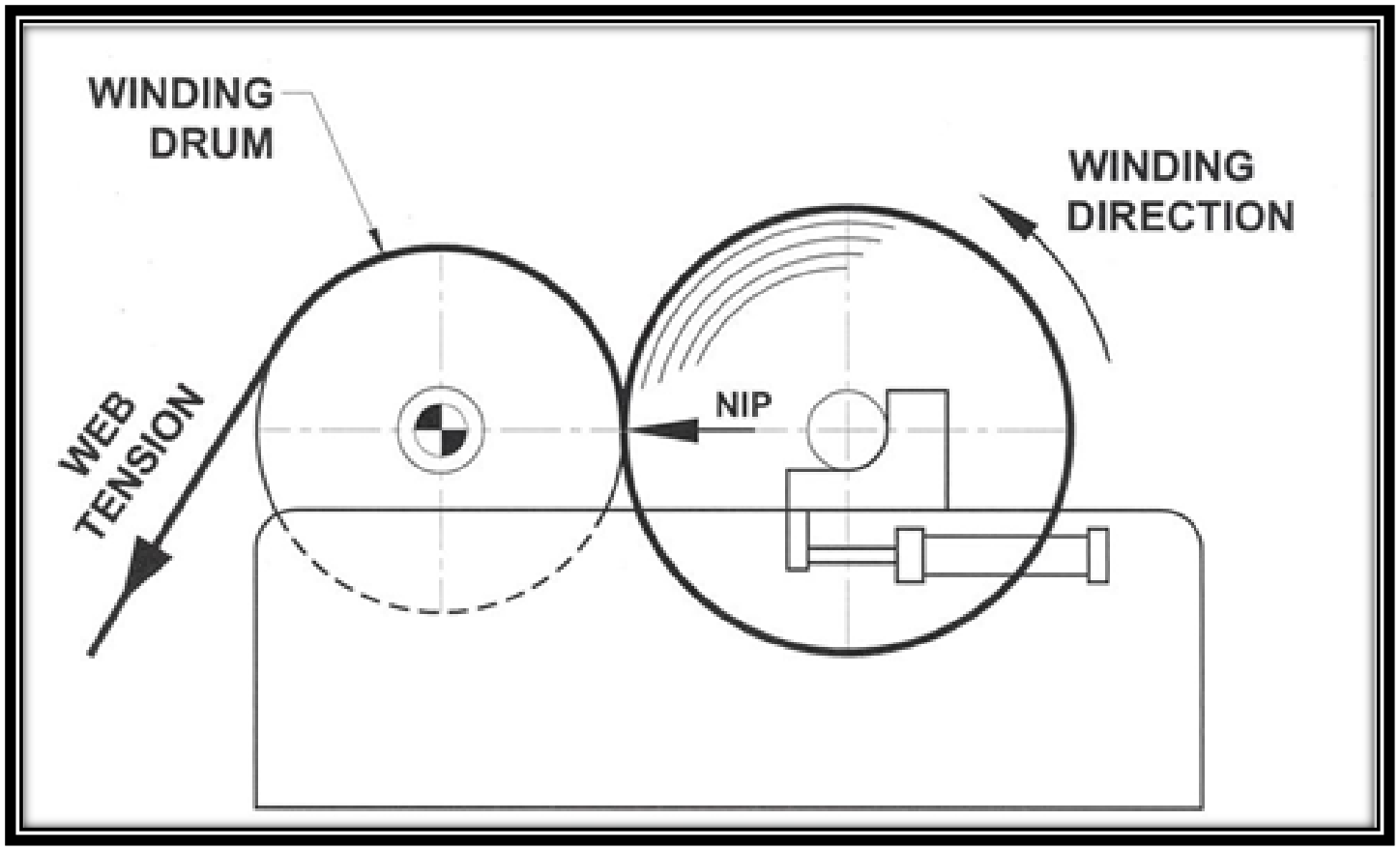
Three Basic Types of Winders w/ variations

1. **Surface Winders -**
2. **Center Winders**
3. **Center/Surface Winders**

EACH TYPE USES ONE OR MORE OF THE T.N.T. PRINCIPLES TO BUILD ROLL HARDNESS

SINGLE DRUM SURFACE TYPE WINDER

Nip is Dominate Winding Principle



SINGLE DRUM SURFACE TYPE WINDER

Continuous Surface Winding

- ***Extensible*** *Type Materials* -

  Uses **T**ension and **N**ip to control hardness

- ***Non- Extensible*** *Type Materials* -

  Web Tension Has Little Affect on Hardness

SINGLE DRUM SURFACE TYPE WINDER

Advantages: Continuous Surface Winding

- Winds Large Dia. Rolls of Material at High Speeds
- Low Horsepower Requirements
- Roll's Weight Does Not Affect Nip

Disadvantages: Continuous Surface Winding

- Must be Shafted Operation
- Limited Control of Roll Density

SINGLE DRUM SURFACE TYPE WINDER

Application: *For Continuous Shafted Winding*

Use for:

- Non-extensible Films
- Heavier Papers & Board Grades
- Extensible Nonwovens

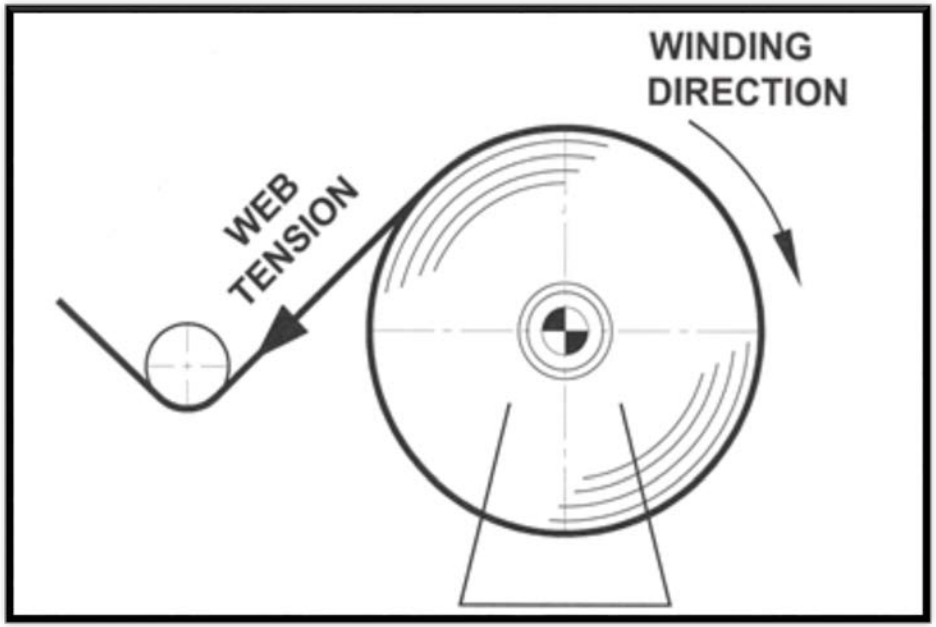
Good application for in-line slitting of these materials

Film Drum Surface Winders

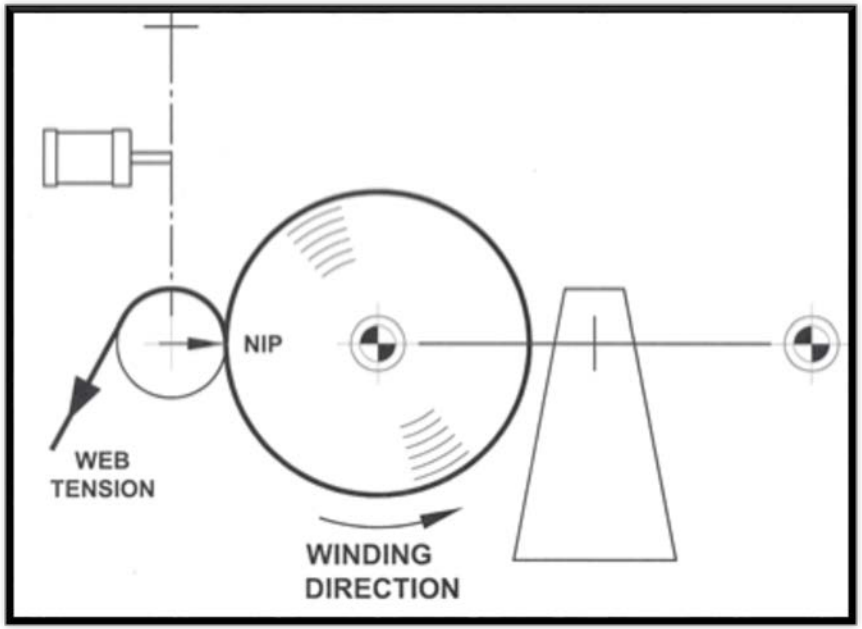
Paper & Nonwoven Drum Surface Winders

CENTER TYPE WINDERS

Tension or Tension & Nip are Dominate Winding Principles



Single Position Pure Center Winder



Continuous Turret Type Winder With Nip Roll

CENTER TYPE WINDER

Application:

Normally used for ***Lighter Grades***

Which are wound at ***Lighter Tensions***

And/or wound to ***Smaller Diameters***

Pure Center Winder
with Pressure Roll

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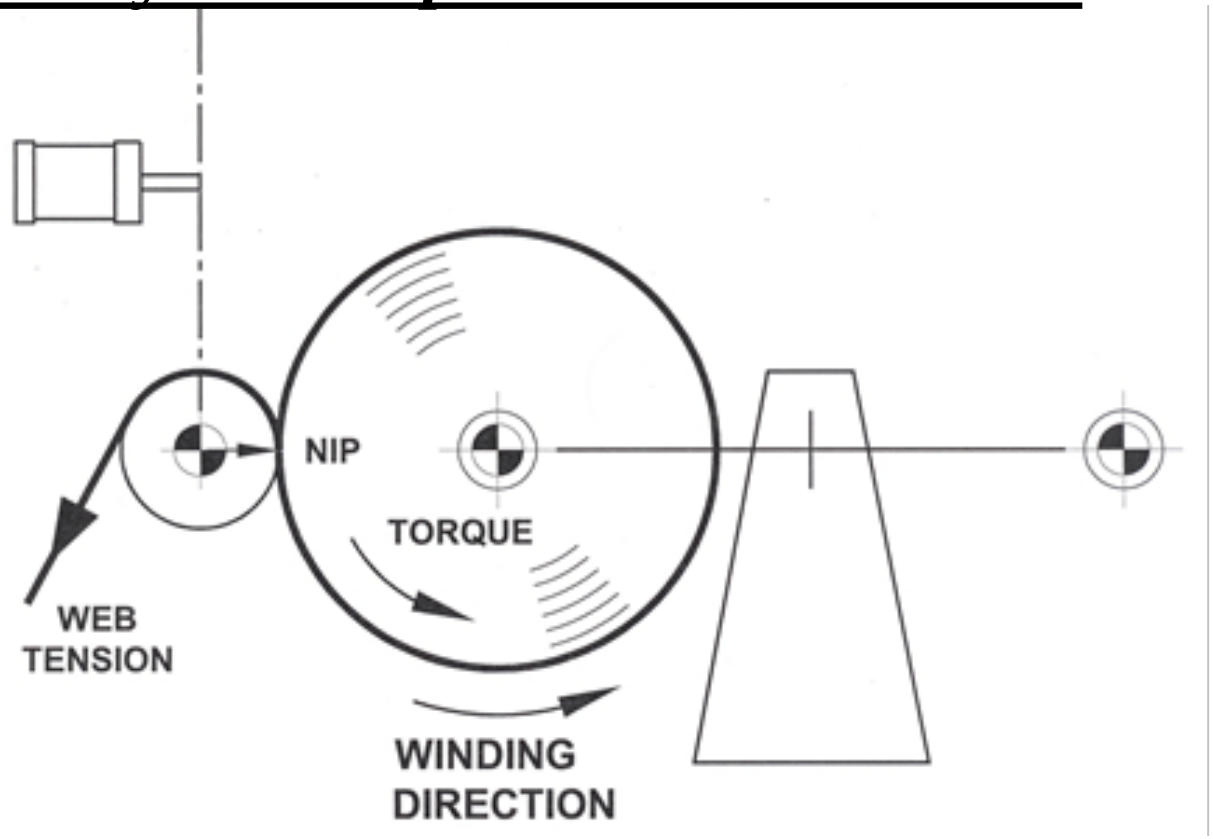
CENTER/SURFACE TYPE WINDER

All 3 of the Tension, Nip & Torque Winding Principles are Independently used to produce Roll Hardness



Continuous Turret Center/Surface Winder

Tension Principles of C/S Winding

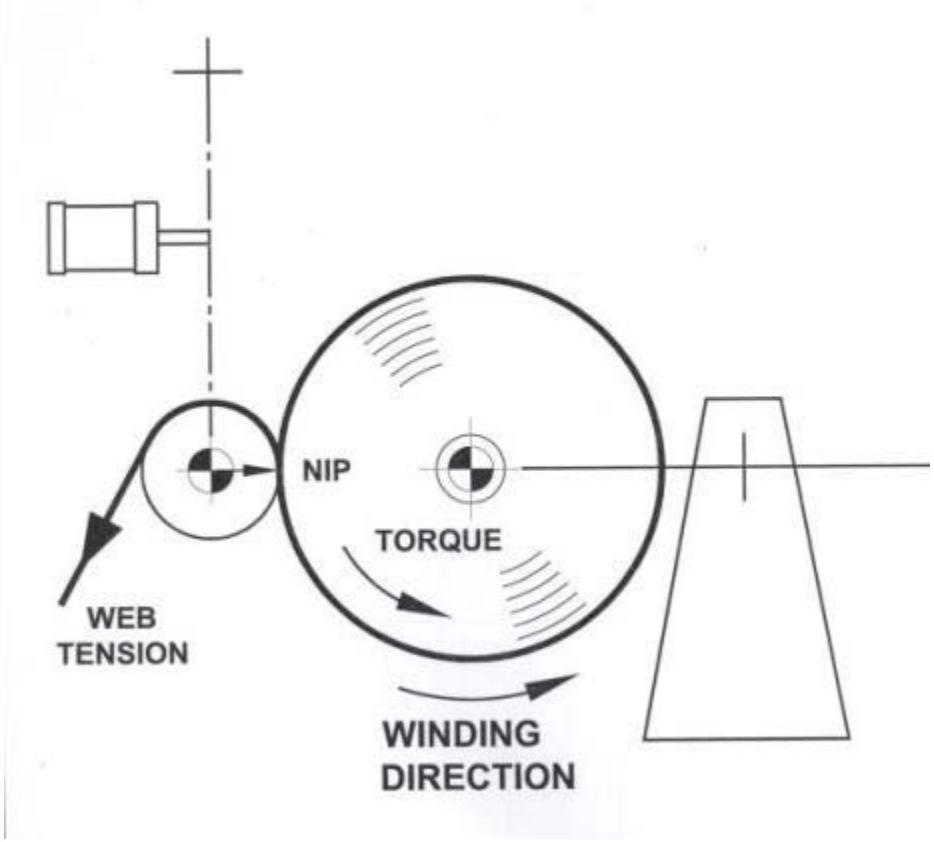
- **When Center/Surface Winding, the web tension is normally held constant which allows the web to be strained (stretched) the same from the start to the finished roll's diameter.**
- **When slitting, this constant tension keeps the spreading and/or "neck-in" constant during the winding process.**

TORQUE Principles of C/S Winding

Center/Surface Winding, the winding tension starts at 25-50% greater than the incoming web tension and then this winding tension is tapered as the roll builds in diameter to a value at or even less than the incoming web tension.

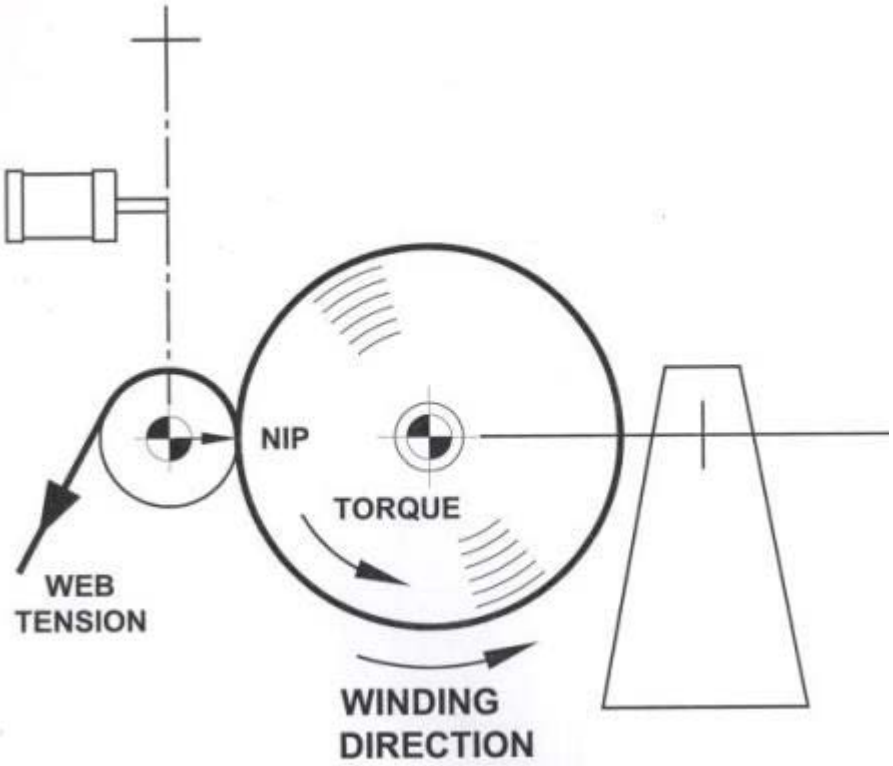
- **<u>Web</u> Tension – Closed Loop control from pressure roll's drive.**
- **<u>Winding</u> Tension is Open Loop control from spline's drive**

Center/Surface Pressure Roll's Indication of Winding Tension



At the start of the wind, the pressure roll's drive will be pulling negative (braking) torque as the Winding Tension is > Web Tension

Center/Surface Pressure Roll's Indication of Winding Tension

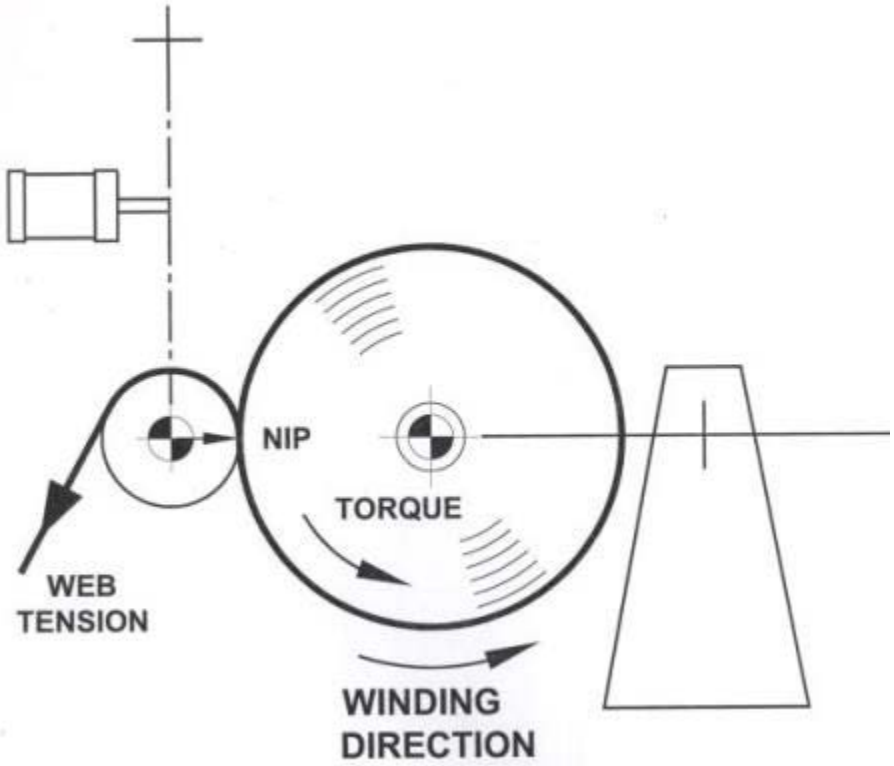


When:

Winding = Web Tension

The pressure roll's drive will be pulling Zero Torque.

Center/Surface Pressure Roll's Indication of Winding Tension



If the winding tension is tapered to less than the web tension:

The pressure roll's drive's torque will be positive (pulling the web tension).

Web > Winding Tension

Center/Surface Winders

- **Best for winding slippery webs**
- **Best for slitting and winding to larger rewind diameters**
- **Best for ability to significantly taper in-wound tension without affecting the width of extensible webs**
- **Able to supply web tension coming into the winder without stretching the web over caliper bands**

Tech Tip- When to Use Center/Surface Winders

When to Use CENTER/SURFACE WINDING

Center/Surface type winders are used when winding slippery materials, when inline slitting, and for turret winders which require pulling high web tensions. On this type of winder, the web tension is pulled by the surface roll's drive and the roll hardness is developed independently from the web tension by the profiled nip from the surface roll and the profile torque from the center drive. Thus, the name "**Center/Surface Winder.**"

When winding slippery materials, the Center/Surface Winder helps to prevent internal web slippage called "cinching" and roll "dishing" during the winding operation. These slippery materials often do not have the required layer-to-layer coefficient of friction to transmit the torque required to pull the web tension at larger roll diameters without web slippage.

For Information on how to get a copy of any of my Tech Tips or Technical Papers - Please give me your card with Email address

"The Art of Winding"

Developing roll hardness is more of an Art than a Science.

SETTING AND PROGRAMMING OF TENSION, NIP & TORQUE WILL VARY DEPENDING ON:

- ***Type & Design of Winder***
- ***Type of Web Material***
- ***Width of Rolls Being Wound***
- ***Speed of Winding Operation***

"The Art of Winding"

The best combination of the roll hardness tools often needs to be empirically determined.

However,
After these are determined for your specific products-

HARDNESS PROFILE MUST BE REPRODUCED CONSISTANTLY

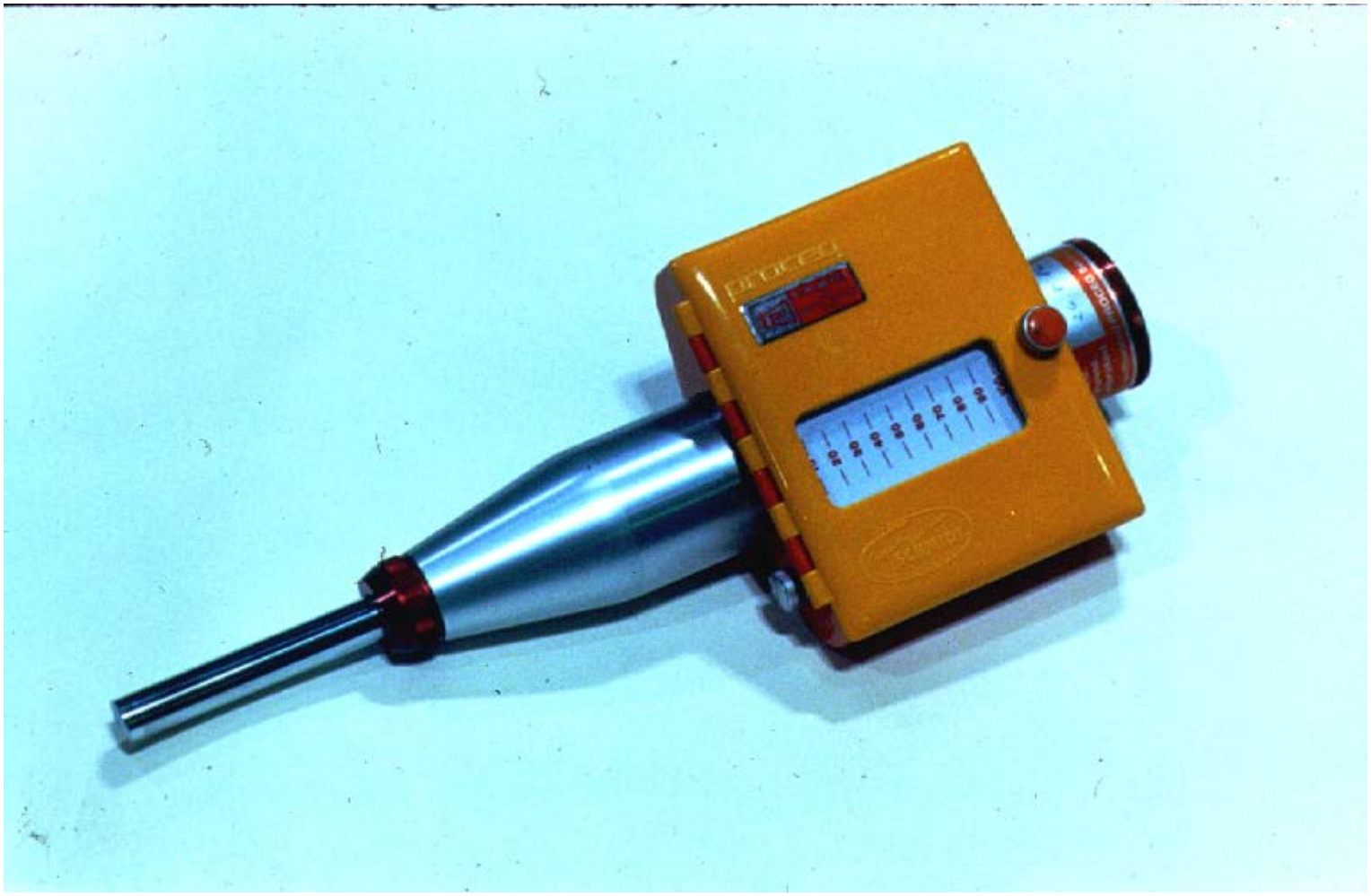
MEASURING ROLL HARDNESS

ROLL HARDNESS MEASURING DEVICES NEED TO BE AVAILABLE TO WINDER OPERATORS

- *RHOMETER & SCHMIDT HAMMER* -
  Measures Hardness Across Outer Surface
- *PAROtester & TAPIO RQP (Roll Quality Profiler)*-
  Measures Hardness Across Outer Surface
- *SMITH NEEDLE* -
  Measures Hardness Core to Full Roll
- RDF Curve (AccuWind) -
  Measures Roll Density During Winding

RHOMETER

SCHMIDT HAMMER

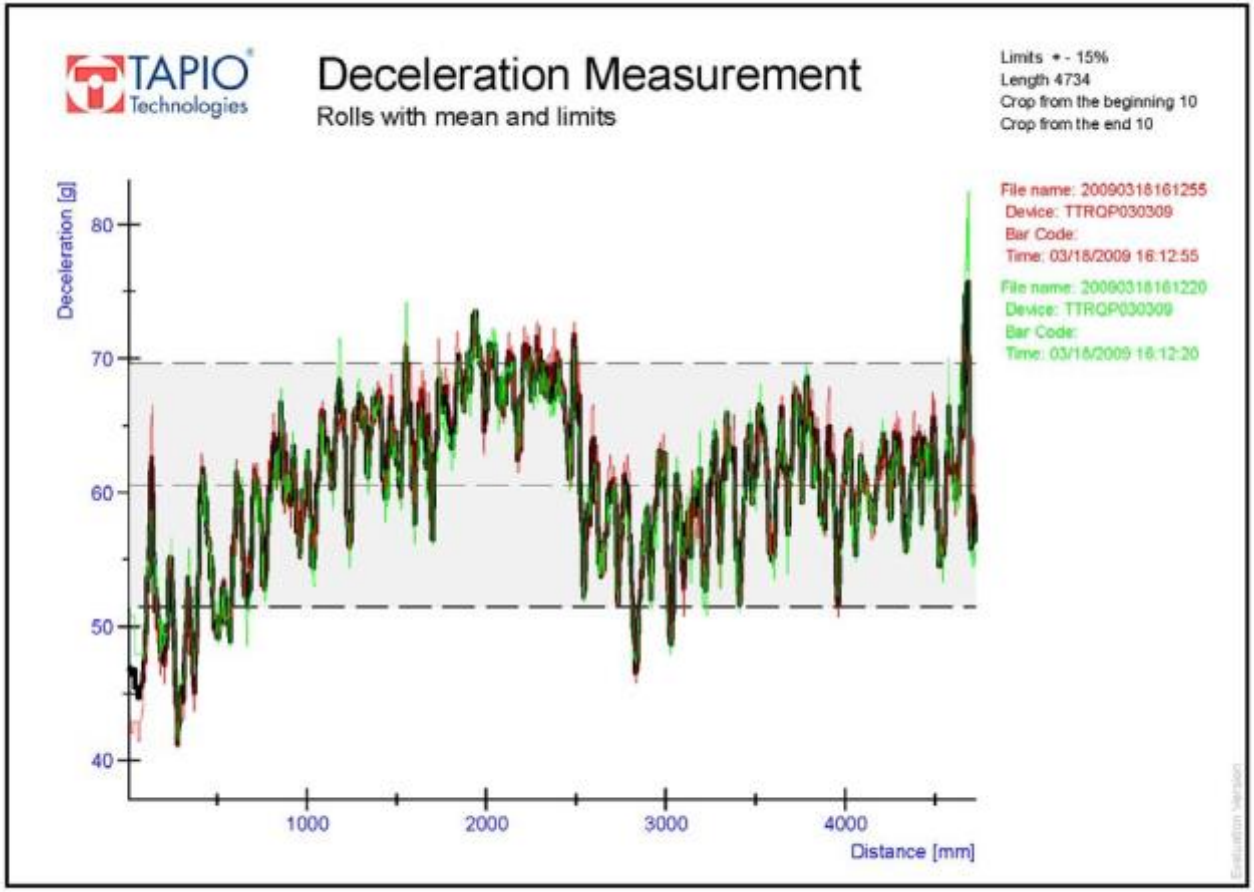


PAROtester

PAROtester

TAPIO RQP (Roll Quality Profiler)-

TAPIO RQP (Roll Quality Profiler)-



Technidyne RoQ Profiler-

- Barcode Scanning Technology, Wireless Communication

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SMITH NEEDLE

Indication of Tapered Roll's Hardness from Core to Full Roll Dia.

AccuWind ROLL DENSITY CURVES

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Roll Hardness Measuring Devices

For Contact Information on where you can get more information on these Roll Hardness Measuring Devices,

Please Email me at:

dsmith@davis-standard.com

"The Art of Winding"

Developing roll hardness is more of an Art than a Science.

SETTING AND PROGRAMMING OF TENSION, NIP & TORQUE WILL VARY DEPENDING ON:

- ***Type of Web Material***
- ***Width of Rolls Being Wound***
- ***Speed of Winding Operation***
- ***Type & Design of Winder***

Product Parameters each type of winder is best suited for:

Suggested Winding Process

1 – Center Winding Process

2 – Surface Winding Process

3 – Combination Center / Surface Winding Process

Material Characteristics	Suggested Winding Process
Thin Webs processed at High Speeds	**1** Contact Mode
Thin Non-Extensible Webs - Small Dia.	**1** Gap or Contact Mode
High Coefficient “Sticky” Materials	**1** Gap Mode
Extensible “stretchy” Webs - Small Dia.	**1** Gap or Contact Mode
Extensible “stretchy” Webs - Large Dia.	**2, 3**
Thick Webs wound to Large Diameters	**2, 3**
Inline Slitting Extensible Webs	**2, 3**
Inline Slitting in Non-Extensible Webs	**3**
Thin Non-Extensible Webs - Large Dia.	**3**
Low Coefficient “Slippery” Materials	**3**

In the past 25 minutes we have discussed

- ***The Importance of Roll Hardness***
- ***Winding Principles used to develop roll hardness.***
- ***How these are used on different types of winders.***
- ***Presented the Product Parameters that each type of winder is best suited for.***

I hope that we have meet our Goal of-

Helping you gain a better understanding for determining the best type of winder for consistently producing quality, defect free rolls of your web materials.

"Guidelines for Selecting the Best Winding Process"

Questions?

If you would like to receive a link where you can order any or all of my Articles & Tech Tips.

Please email me at dsmith@davis-standard.com

Thank You

Guidelines for Selecting the Best Winding Process

2017 AIMCAL Web Handling Session

Naples , FL.

Presented by

R. Duane Smith

Process Manager

Web Handling & Specialty Winding