Challenges of Winding Flexible Packaging Films

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Challenges in Winding Flexible Film

If all film webs were perfect, then the ability to produce perfect rolls of film products wouldn't be much of a challenge.

Unfortunately, due to the natural variation in resins, non-uniformities of the film formation processes, coatings and printed surfaces, there is no such animal as a perfect film.

Challenges in Winding Flexible Film

It is NOT the winding operation's responsibility to camouflage poor quality film products.

However, it is the winding operation's challenge is to wind film webs with slight imperfections that do not stand out in appearance and are not amplified during the winding process.

Challenges in Winding Flexible Film

The ultimate challenge is to wind flexible packaging film that will run on your customer's process without problems and produce high quality products for their customers.

Challenges in Winding Flexible Film

Roll density, or in-wound tension, is the most important factor in determining the difference between good quality and poor quality rolls of film products.

Proper roll hardness is extremely important to be sure that high quality rolls are produced, handled and stored, shipped and then-

Processed by your customers at maximum production speeds without product defects.

Presentation Goal:

To develop an understanding of the roll hardness principles and
how these are used on film winders
to wind rolls with the proper
hardness profile to consistently produce quality roll of Flexible Packaging Films.

"The Art of Winding"

Developing roll hardness is more of an Art than a Science.
The best combination of the roll hardness tools often needs to be empirically determined.

"Rules of Thumb"

However, in this presentation we will be suggesting some "Rules of Thumb" for the starting values for different web materials to assist in optimizing the wound roll hardness profile to meet your Customer's needs.

This presentation –based on an article published in
Plastics Technology – September 2015


PT Tips and Techniques

Overcome the Challenges in Winding Flexible Packaging Film

Not all film webs are created equal. This creates challenges for both winder and operator. Here's how to handle them.

A winder operator's job is to handle films with slight imperfections and to produce quality rolls that will run without problems on the downstream customer's process.

WHAT YOU WILL LEARN

Tension Principle on a Center Winder

Tension and Nip Principles on a Center Turret Winder

Center/Surface Winder with Driven Pressure Roll

The Importance of Roll Hardness

Rolls that are wound too soft will go 'out-of-round' while winding or while being handled or stored. The roundness of rolls is very important in a customer's operation to enable processing these rolls at maximum production speeds with minimal tension variations.

The Importance of Roll Hardness

Film Rolls Wound Too Soft Cause Processing Problems

The Importance of Roll Hardness

Rolls that are wound too tight will also cause problems.

- **Tightly wound rolls of films can have blocking problems.**
- **When winding extensible film on thin wall cores, winding hard rolls can cause the cores to collapse.**
- **Rolls that are wound too tightly will exaggerate slight web defects.**

The Importance of Roll Hardness

Typically, films will have slight high and low areas in the cross machine profile where the web is thicker or thinner. When winding hard rolls, the high caliper areas build on each other. As hundreds, even thousands of layers are wound; the high areas form ridges, or high spots, in the roll. As the film is stretched over these ridges, it is deformed.

The Importance of Roll Hardness

Hard rolls that have high gauge bands next to low gauge bands will produce a roll defect known as corrugations, or rope marks, in the rolls.
Then, when the roll is unwound, these areas produce a defect known as "bagginess" in the film.

Slight variations in thickness will not be noticeable in a wound roll if sufficient air is wound into the roll in the low areas and the web is not stretched over the high areas. Still, the rolls must be wound hard enough that so they will be round and will stay that way during handling and storage.

Randomization of Cross Machine Variations

Some flexible packaging films, either by their extrusion formation process or by their coating and laminating process, have cross machine variations of thickness too severe to be wound without exaggerating these defects.
To randomize cross machine variations in the wound rolls- either the web or the slitters and winder are moved back and forth relative to the web being wound.
This randomizing cross machine movement is called oscillation.

Oscillation Speed

For successful oscillation the speed must be fast enough to randomize thickness variations and slow enough that it does not strain or wrinkle the film.

- The *rule of thumb* for the maximum oscillation speed is 25mm (~1") per minute per 150 mpm (500 fpm) winding speed.
- Ideally the oscillation speed varies proportional to the winding speed.

The Importance of Roll Hardness

As Stated earlier-

Roll Hardness is the critical factor in determining the difference between a good quality roll & a poor quality roll.

Secret to building a good structure

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

Secret to winding a Quality Roll

Start Winding with a good solid foundation:

- **Use quality & properly stored cores**
- **Start Winding with as much Roll Hardness as possible**

Then wind with progressively softer roll hardness:

- **Use as much taper of the Roll Hardness tools as possible.**
- **The larger the winding roll's finished diameter the more hardness taper is required.**

Profiling Roll Hardness

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

If stresses become greater as roll winds larger - <u>inner wraps</u> towards the core <u>will loosen & may even go into compression.</u> This usually happens as the roll of flexible package materials cures after winding.

These compressive loads causes rolls defects such as telescoping, buckling and/or starring

Telescoping, Buckling and Starring Roll Defects

Telescoping Buckling Starring Defects

ROLL HARDNESS MUST BE PROFILED TO PREVENT THESE!

Secret to building a good structure

The greater the Build-up Ratio =

Finished Roll Diameter / Core OD

The more important the hardness of start and the hardness taper becomes!

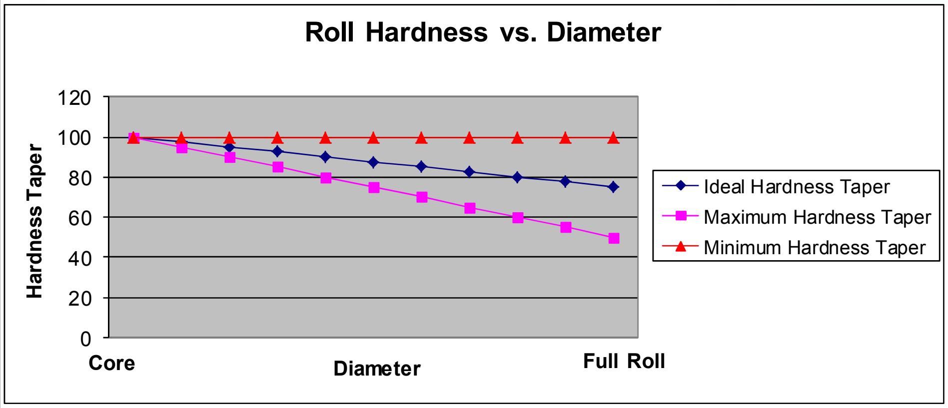
Building a 12 story building (a 48” roll diameter on a 4” core OD) - the foundation and structure is much more critical than building a 4 story building (a 16” roll diameter on a 4” core OD).

Rules of Thumb for Roll Hardness Taper

- **25% on 3-5 to 1 Build-up ratio***
- **33% on 6-8 to 1 Build-up ratio***
- **50% on 9-12 to 1 Build-up ratio***

***Build-up ratio is Wound Roll Dia./ Core O.D.**

Roll Hardness Profiles



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 Tools to develop Roll Hardness

The three winding tools used for consistently winding dynamite rolls are:

T.N.T.

T.N.T. Winding Tools to Develop Roll Hardness :

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

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

***T**orque* - The **T**orque from the Center Drive

Using the T.N.T. Tools to Develop Roll Hardness

Using the T.N.T. Tools to

Develop Roll Hardness

Tension - The WEB's Tension

Extensible Films- Web Tension is Dominant Winding Principle

The more stretch put into the web before winding it, the tighter the wound rolls will be.

"Rule of Thumb" for Web Tension

Web Tension = Strain (stretch) put into the web
Function (Mat'l's. Modulus, Width, Thickness)

Strain = Stress/Modulus of Elasticity (E)
= (Web Tension / Area) / Modulus

= Web Tension/(Width x Thickness)/Modulus

The challenge is to be sure that the amount of web tension does not induce significant permanent stresses in the film.

Suggested amounts of Web Tension
"*Rule of Thumb*" is 10%–25% percent of machine direction elastic limit of web material.

How much Web Tension ?

Tech Tip - Web Tension

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Web Tension - English Units

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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 customers 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 10# of tension to stretch a 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 1 pli (pounds per linear inch) of tension with a maximum tension of 2.5 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 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

Tension Principles of Winding

***Rule of Thumb* for Winding Tension -**

Start winding at the higher value of suggested tension levels.

Then smoothly taper this winding tension by 25% to 50% to the finished roll dia.

Example to calculate Suggested Winding Tension

Material	TENSION LEVELS
Polyester	0.5 to 1.5 lbs./inch/mil
Polypropylene	0.25 to 0.5 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

Example – Suggested starting winding Tension

For a 60" wide and 2 mil thick Polyethylene (PE) material would be: 0.3 lbs./inch/mil x 60" x 2 mil

= 36 lbs. total web tension starting web tension

NIP Principle of TNT Winding

Inelastic (non stretchy) webs

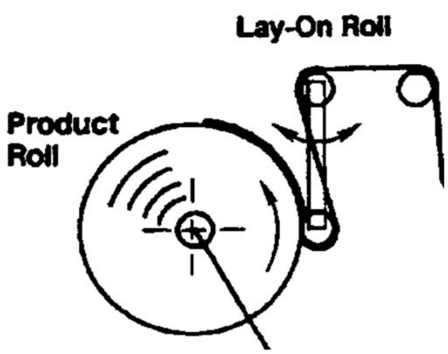
-***N***ip tension is dominant principle of winding in order to control roll hardness

NIP Principle of TNT Winding

Nip of winding rolls

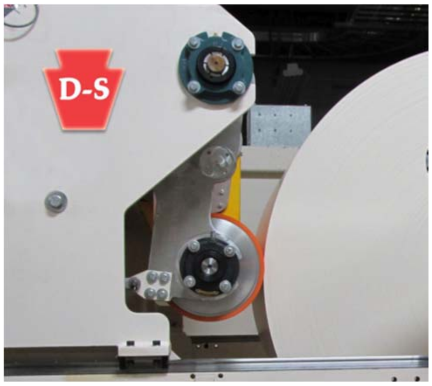
- **Removes the boundary layer of air following the web**
- **Adds inwound tension - the higher the nip, the harder the rolls**
- **Challenge is to have sufficient nip to wind hard and straight rolls without winding in too much inwound tension to prevent blocking and deforming the web over caliper bands**

Nip *Rules of Thumb*:



- **Nip must be applied where web enters the winding roll.**
- **The winding roll's & 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.

Gap Winding

Air sometimes wants to be wound into the winding roll of material to

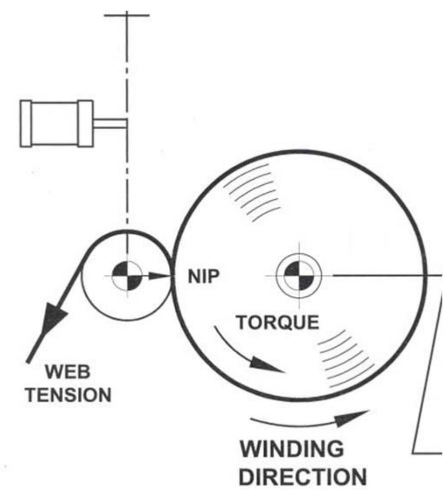
-Prevent blocking problems

-Prevent deforming the web that is wound too tightly over gauge bands

Lay-on roll should follow the winding roll's surface with a small controlled gap

(Directs the web squarely into the winding roll)

Torque Principle of TNT Winding



- The Torque is the force that is applied thru the center of the winding roll.
- The Torque applied cinches (tightens) the winding layers to increase the roll's hardness.

Film's Coefficient of Friction Properties Effect on Winding

Film's layer to layer coefficient of friction properties have a major effect on the ability to apply the T.N.T. principles to produce the desired roll hardness without roll defects.

Films with coefficient of friction (COF) value between 0.2 to 0.7 will generally wind well.

However, consistently winding defect free rolls of high slip or low slip (low COF or high COF) films usually presents major winding challenges

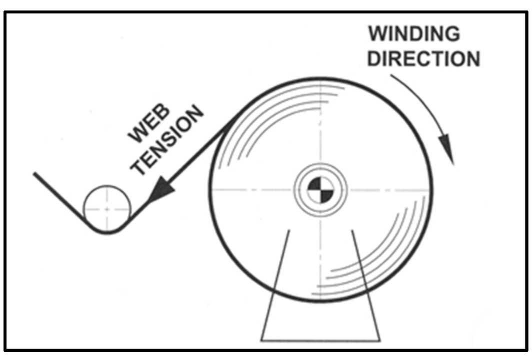
Film's Coefficient of Friction Properties Effect on Winding

High slip films (COF< 0.2) often have inner web slippage or cinching problems that can result in defects such as web scratching, dishing, telescoping and/or starring roll defects.

Low slip films (COF >0.7) often have blocking and/or wrinkling problems and may have roll bouncing problems.

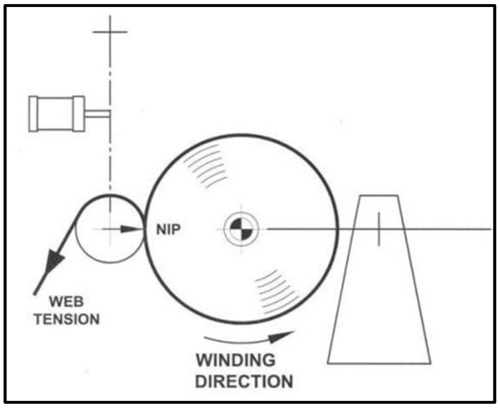
See text for complete discussion of *Film's Coefficient of Friction Effect on Winding* .

Pure Center Type Winders



Only roll hardness tool is Web Tension which is produced from winding Torque with Transducer feedback and trim.

Center Turret Type Winder with a Nip Roll



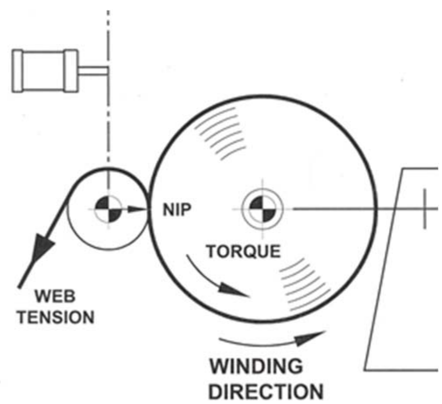
Contact Winding:

Tension & Nip roll hardness tools are used to control the winding roll's hardness profile

Note- Web tension provided by spindle torque

Pure Center Winder with Pressure Roll

Center/Surface Type Winder with a Driven Pressure Roll



Winding Torque Principle is used to control roll's hardness independent from the web's Tension.

C/S Winders - All three TNT winding principles independently controlled to optimize the roll's hardness profile.

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.

"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

TO INSURE WINDING ROLLS WITH CONSISTANT ROLL HARDNESS- HARDNESS MEASURING DEVICES NEED TO BE AVAILABLE TO WINDER OPERATORS

Please refer to presentation preprint and written paper for information on suggested roll hardness measure devices.

Roll Defects Due to Roll Hardness

- Out-of-round rolls
- Roll blocking
- Ridges
- Tin Canning
- Corrugations or rope marks in wound rolls

"Art of Winding"

Article *Paper Film & Foil Converting*

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Other Visual Defects to Avoid for Consistently Winding Quality Rolls

- Poor starts
- Core offsets
- Splices
- Offsets and interweaving
- Dished or telescoped rolls
- Starred rolls
- Trim wound in rolls
- Slitter rings
- Other slitter defects such as
  - Excessive slitter dust
  - Nicked edges
  - Scalloped edges
  - High edges

The Ultimate Roll and Web Defect Troubleshooting Guide
is the updated and expanded version of TAPPI Press's Best Seller
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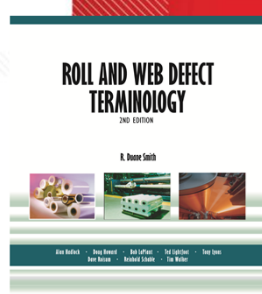

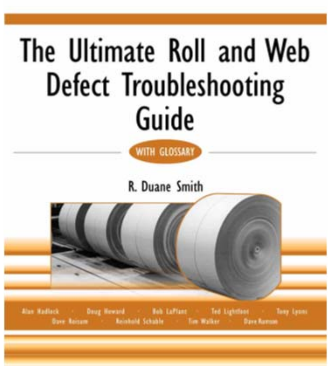

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- Defects - web handling defects
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The Ultimate Roll and Web Defect Troubleshooting Guide

TAPPI - ROLL AND WEB DEFECT TERMINOLOGY

CLASSIFICATION:
- SLITTER DEFECTS - ROLL EDGE
- REF. NUMBER RD-50

ROLL EDGE - SLITTER RINGS

SYNONYMS

ALSO KNOWN AS: SLITTER RINGS, ANNULAR RINGS, BULLS-EYE ROLL, TARGET RINGS.

DEFECT DESCRIPTION

Slitter Rings: Appear as concentric annular ring patterns on the edges of the roll that give the roll edge the appearance of a target. This defect is very common on winders with mandrel-mounted bottom knives after the mandrel has been reground one or more times. Note: this defect is caused by the slitter, but shows up as a roll edge defect. It is also listed as a slitter defect.

CAUSES OF SLITTER RINGS

Slitter rings are formed by wobbling lower knife rings which form a cambered-edge (SD-1) slit line in the form of a sine wave. As successive layers of the cambered slit edges are wound into the roll, diameters are reached which correspond to a mathematical relationship between the roll circumference and the length of the slit edge sine wave. At these diameters, the characteristic "slitter rings" will form.

Typical causes of slitter rings include:
1. Excessive slitter runout due to non-concentric grinding of bottom knives. Normal maximum is 0.05-0.1 mm (0.002-.004 inches).
2. Wobble of bottom knife rings due to poor fit on mandrel or hub.
3. Bent lower slitter shaft or slitter mounting spindle.
4. Extremely narrow lower ring "tilts" on mandrel.

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TAPPI - ROLL AND WEB DEFECT TERMINOLOGY

CLASSIFICATION:
- SLITTER DEFECTS - ROLL EDGE
- REF. NUMBER RD-50

ROLL EDGE - SLITTER RINGS

When bottom slitter knife wobble is not present and a common pattern is found on all rolls, other non-slitting related causes, such as tension variables, bowed roll (spreader) influences, machine alignment, or machine harmonics may be indicated.

REMEDIES FOR SLITTER RINGS

1. Ensure that slitter rings are properly fixtured when grinding so that eccentric edges will not be ground into the rings.
2. Ensure proper clearance tolerance between the knife ring I.D. and its mounting shaft or hub. With hub mountings, be sure surfaces are clean and tighten screws evenly, working progressively around in a circle.
3. Check for bent-spindle wobble and correct if necessary.
4. Where extremely narrow lower rings are used, it may be possible to stack two or more rings against each other to reduce wobble.

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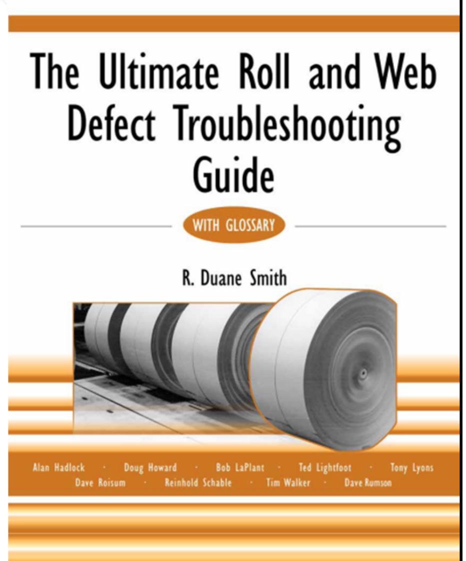


Conclusion- Challenges of Winding Flexible Pkg. Films

During this presentation we have:

- **Discussed the Importance of Roll Hardness**
- **Presented the Roll Hardness Principles**
- **Explained how these are used as tools on Center and Center/Surface Winders to build Roll Hardness**
- **Suggested some "Rules of Thumb" for starting values and tapers for these T.N.T. Roll Hardness tools.**
- **Presented information on the valuable resource tool "The Ultimate Roll and Web Defect Troubleshooting Guide"**

Conclusion- Challenges of Winding Flexible Pkg. Films

I hope that the information presented will assist you in perfecting this "Art" of winding your flexible packaging film products so that your high quality web materials are produced, handled and stored, shipped and then processed by your customers at maximum production speeds without defects.

"Art of Winding" Article

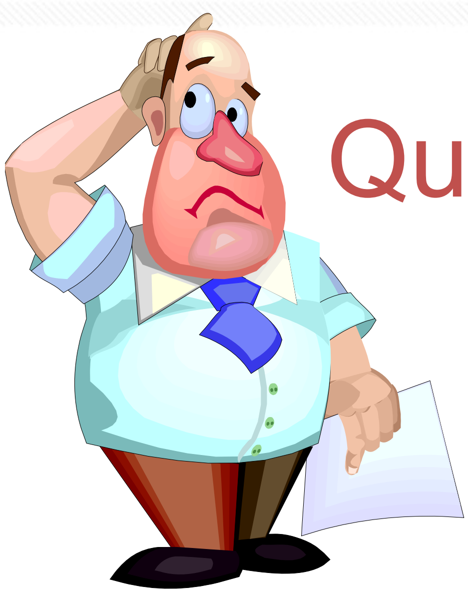
Reminder

If you would like to receive a copy of my *"Art of Winding"* article,
Tech Tip on *Guidelines on Web Tension*
and more information on Roll Hardness measuring devices.

Please give your business card with "Art of Winding" written on it.

Will also send you a link where you can order any or all of my Articles & Tech Tips.

Challenges of Winding Flexible Pkg. Films



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