

# **Challenges in Winding Flexible Packaging Film**

**By R. Duane Smith**  
**Product Manager- Specialty Winding**  
**Black Clawson Converting Machinery**  
**Davis Standard LLC**  
**Fulton, New York, USA**

## **Abstract**

Every Flexible Film Producer is faced with the challenge of producing quality rolls of film products. This paper will assist in overcoming the challenges in winding flexible packaging films. It addresses the definition of a quality roll of film and the importance of in-wound tension in consistently producing good quality rolls. It then discusses the winding principles used on all winders to control in-wound tension or roll hardness. It explains how to determine the proper amount of web tension for various types of films and the principles of nip and gap winding. Then the basic types of center, surface and combination center/surface winders will be compared with the advantages and disadvantages of each. After the discussion of how roll hardness is achieved, methods of measuring roll hardness are presented. Finally, other roll defects to avoid in producing quality rolls of film will be listed and the book "Roll and Web Terminology" will be brought to the audience's attention for them to learn more about the causes and cures of common roll and web defects.

## **Introduction**

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 and additives and non-uniformities of the film formation processes, there is no such animal as a perfect film. The winding operation's challenge is to wind film webs with slight imperfections being sure that these slight imperfections do not stand out in appearance and are not amplified during the winding process. Then it is the responsibility of the winder operator to make sure that the winding process does not produce additional variations in the product quality. The ultimate challenge is to wind Flexible Packaging Film Webs with slight imperfections and produce quality rolls that will run on your customer's process without problems and produce high quality products for their customers.

## **Definition of a Quality Roll**

If the challenge is to wind quality rolls of flexible packaging film webs, then the first task is to define our customers' definitions of good quality. A baker will tell you that in order to please their customers, they must produce rolls that are of the right shape, the right size, the right consistency – not too hard and not too soft, they must look good – no blemishes or visual defects, and they must have a good aroma. A film product customer wants rolls of film that are:

The right shape	-Round and proper width
The right size	-Right diameter or length
The right consistency	-Proper roll density - not too hard or soft
Must look good	-No blemished or visual defects
Aroma?	-Well, start shipping your customers bad rolls of film and they are going to raise a stink !!!

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. Rolls that are wound too soft will go out of round while winding or will go out of round while being handled or stored. The roundness of rolls is very important in your customer's operation. When unwinding out of round rolls, each revolution will produce a tight and slack tension wave. These tension variations can distort the web and cause register variations in the printing process. The only way to minimize the effect of these tension variations is to run the operation at a much lower speed, which greatly affects the production process.

Rolls that are wound too tight will also cause problems. Rolls of some films, when wound too tightly will "block". Roll blocking is a defect where the sheet layers fuse or adhere together. When winding extensible film on thin wall cores, winding hard rolls can cause the cores to collapse. This can cause problems in removing the shaft, or with inserting the shaft or chucks on the subsequent unwinding operation. Tightly wound rolls contain high residual stresses or high in-wound tension. The film will stretch & deform as these stresses are relieved as the rolls cure during storage.

Rolls that are wound too tightly will exaggerate web defects. No web is perfectly flat or the same thickness from one side to the other. Typically, webs will have slight high and low areas in the cross machine profile where the web is thicker or thinner. When winding hard rolls of film, the high caliper areas build on each other. As hundreds, even thousands of layers are wrapped creating a roll, the high areas form ridges or high spots in the roll. As the film is stretched over these ridges, it is deformed. Then when the roll is unwound, these areas produce a defect known as bagginess in the film. 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.

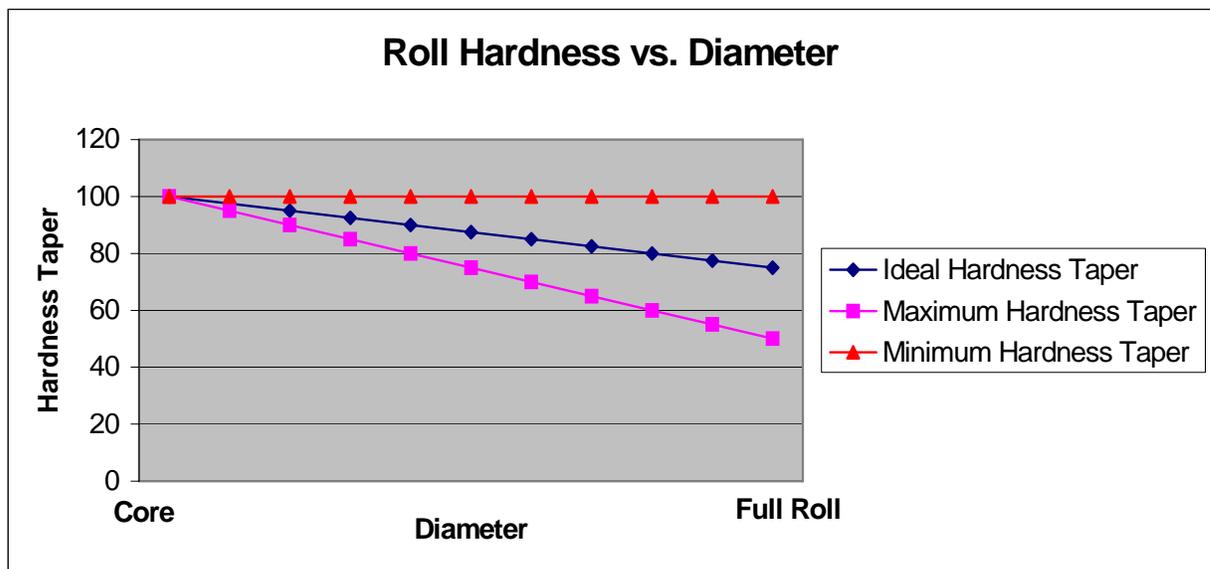
Slight defects of these types will not be noticeable in a wound roll if sufficient air is wound into the roll in the low areas and the web is not stretched over the high areas. Still the rolls must be wound hard enough that so they will be round and will stay that way during handling and storage.

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 overcome this, these webs are moved back and forth as they are being slit and wound, or the slitters and winder can be moved back and forth relative to the web. This is called oscillation, which randomizes these localized defects across the wound rolls. Oscillation may be either a ‘constant speed / stop / constant speed back’, or ‘a sine type wave of speed curve’. What is important is that the oscillation speed is fast enough to randomize defects and slow enough that it does not strain or wrinkle the film. Additionally the rolls, after they have been slit, are wound with straight edges. The rule of thumb for the maximum oscillation speed is 25mm (~1”) per minute per 150 mpm (500 fpm) winding speed. For best results, the oscillation speed should vary proportional to the winding speed.

### How to Achieve and Measure Roll Hardness

Now we know why roll hardness is important. Next let’s discuss how to achieve and measure roll hardness. As a roll of flexible packaging film material winds, tension builds inside the roll, which is known as in-wound tension or residual stress. If this stress becomes greater as the roll is wound, then the inner wraps towards the core will be put under high compressive loads. This is what causes a defect known as buckling of the webs in localized areas in the roll. When winding non-elastic and high slip films, the inner layers will loosen, which can cause the roll to dish while winding or telescope when unwinding. To prevent this, the rolls want to be wound tight at the core and then wound with less tightness as the roll builds in diameter as shown below. The larger the finished rewind diameters, the more critical the roll hardness profile is. See Figure #1.

Figure #1



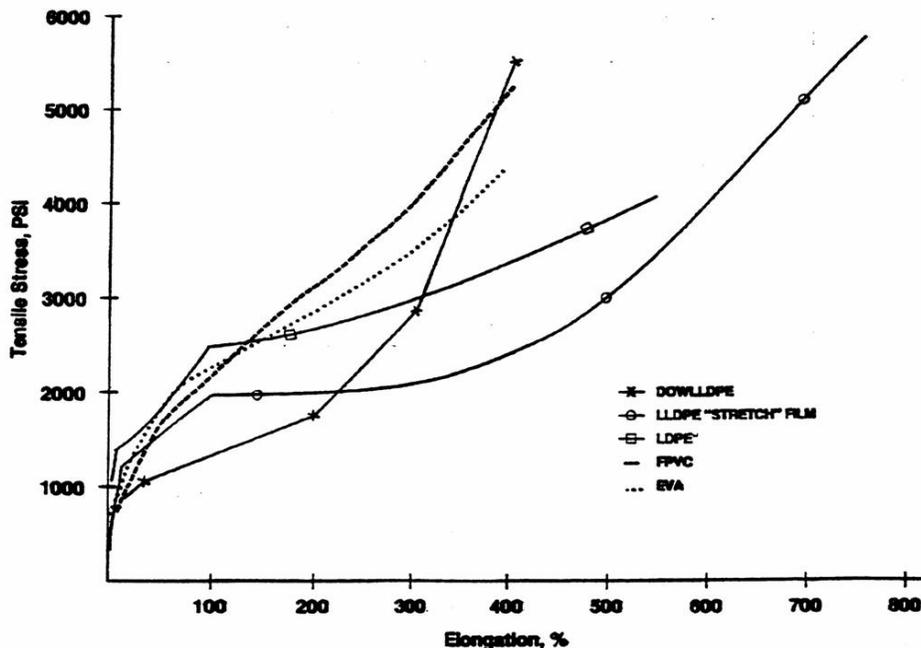
## Film Winding Principles

Roll hardness is developed in different ways on different types of winders but the basic principles of how to build roll hardness are always the same.

To remember these principles, just remember that to consistently wind 'Dynamite Rolls' you need TNT:

<b>T</b> ension	- The Winding Web Tension
<b>N</b> ip	- The Nip of the Pressure Roll or Drum
<b>T</b> orque	- From the Center Drive or Torque Drum

**Web Tension Principle of Winding** - When winding elastic films, web tension is the dominant principle of winding to control roll hardness. The more tension pulled, the more stretch put on the web before winding, the harder the wound rolls will be. The winding web tension is often determined empirically; however, the maximum amount of web tension can also be determined using the modulus of elasticity of the film material. The modulus is the ratio of the stress and strain of the web. Figure #2 shows the stress/strain curves for different types of film. Films, unlike metals, have moduli that are far from linear. By measuring the secant modulus for either 1% or 2% of the strain curve, and then extrapolating it linearly to 100% elongation, we can determine the modulus of elasticity. Table #1 gives typical modulus ranges for films. Empirical data has shown that a tensile stress of 1.5% of the elastic modulus can be applied without inducing significant permanent stress. When only relying on tension to control roll density, it is important that the winding tension is tapered smoothly as the roll diameter increases. The tension taper should be between 0 and 50%. A tension taper of 25% at full roll is common. Tapered tension reduces 'end crowning', 'buckling', 'starring' and 'dishing' roll defects in rolls of flexible packaging film material.



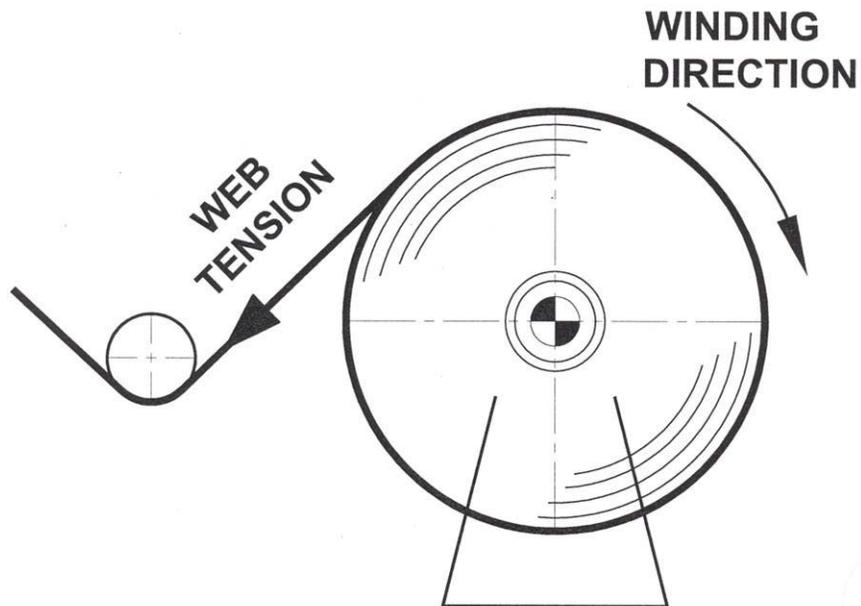
**Strain Curves for Various Film Webs**

**Figure 2**

## Typical Secant Modulus of Elasticity for Films

PVC(flexible)	350 - 560 kg/cm <sup>2</sup> (5-8 kpsi)
LDPE	1,000 - 1,800 kg/cm <sup>2</sup> (15-25 kpsi)
LLDPE	1,400 - 2,100 kg/cm <sup>2</sup> (20-30 kpsi)
HDPE	8,400 - 14,000 kg/cm <sup>2</sup> (120-200 kpsi)
BOPP	7,700 - 24,000 kg/cm <sup>2</sup> (110-350 kpsi)
OPET	35,000 - 42,000 kg/cm <sup>2</sup> (500-600 kpsi)

Table #1



Tension Principle On A Center Winder

### **Example of Determining Maximum Web Tension – Metric**

To determine the maximum web tension to wind 50 microns (.05mm) low density polyethylene (LDPE) film, we need to calculate the tension to stress the film to 1.5% of its elastic modulus. From the preceding ‘Modulus of Elasticity’ chart, we can assume an average modulus of 1,400 kg/cm<sup>2</sup> for LDPE.

$$1.5\% \text{ of } 1,400 \text{ is } .015 \times 1,400 = 21 \text{ kg/cm}^2 = 0.21 \text{ kg/mm}^2$$

If our film sheet is 1500mm wide and .05mm thick, then the cross sectional area is 1500mm x .05mm = 75 square mm.

Therefore the maximum allowable tension would be:

$$0.21 \text{ kg/mm}^2 \times 75 \text{ mm}^2 = 16 \text{ kg Total Web Tension}$$

Try to keep web tension at or below this level during the winding process.

### **Example of Determining Maximum Web Tension – English**

To determine the maximum web tension to wind 2 mil (.002”) low density polyethylene (LDPE) film at, we need to calculate the tension to stress the film to 1.5% of its elastic modulus. From the above ‘Modulus of Elasticity’ chart, we can assume an average modulus of 20 kpsi for LDPE.

$$1.5\% \text{ of } 20,000 \text{ psi} = 0.015 \times 20,000 = 300 \text{ psi} = 300 \text{ pounds/in}^2$$

If our film sheet is 60” wide and .002” thick, then the cross sectional area: 60” x .002” = 0.12 square inches

Therefore the maximum allowable tension would be:

$$300 \text{ psi} \times 0.12 \text{ in}^2 = 36 \text{ pounds Total Web Tension}$$

Try to keep web tension at or below this level during the winding process.

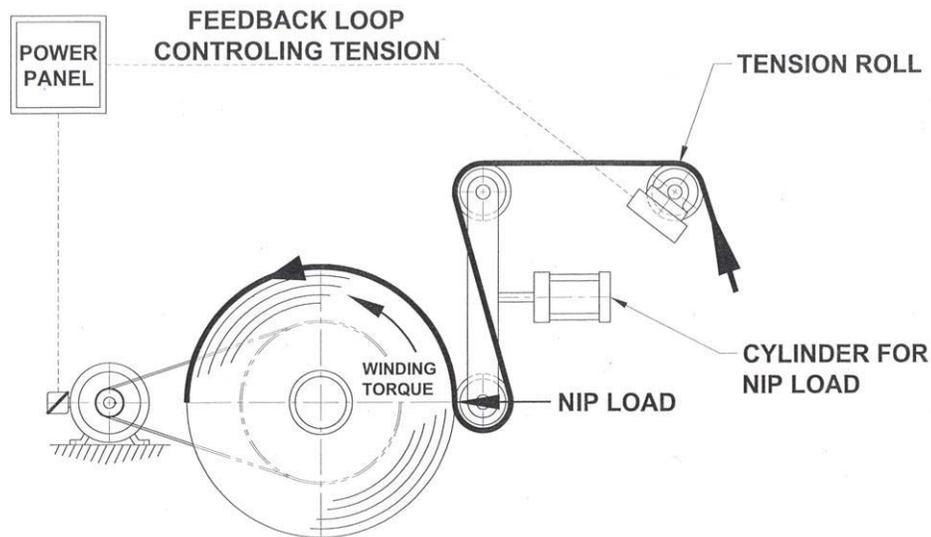
**Nip Principle of Winding**– When winding inelastic films, nip is the dominant principle of winding to control roll hardness. Web tension is controlled to optimize the slitting and spreading operations. The nip controls the roll hardness by removing the boundary layer of air following the web into the winding roll. The rolling nip also induces in-wound tension into the roll. The harder the nip, the harder the winding roll. The challenge for winding flexible packaging film is to have sufficient nip to remove the air and wind hard straight rolls, without winding in too much in-wound tension, to prevent causing roll blocking or deforming the web over the high caliper area.

The important considerations in applying the nip principle of winding are:

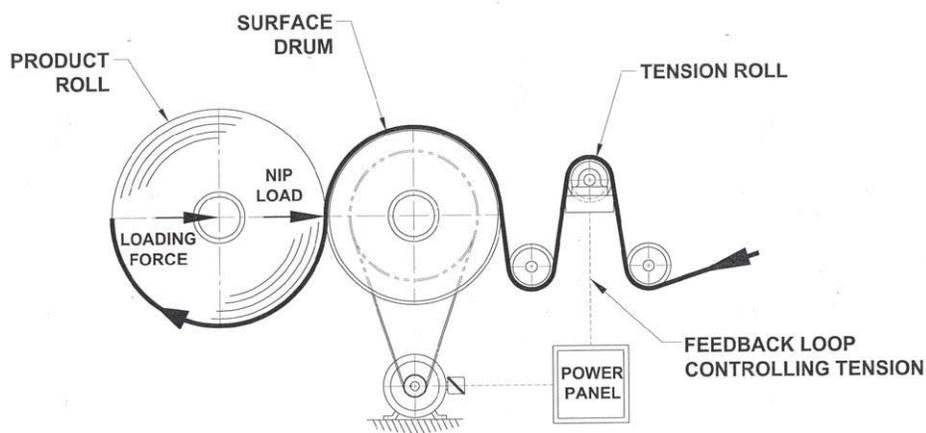
- The nip must be applied where the web enters the winding roll.
- The winding film's weight and the lay-on roll's weight, as well as web tension should not affect the nip loading.
- The nip load should be tapered as the roll winds to prevent 'starring' and 'telescoping'.
- The larger the winding roll's diameter, the more air is introduced to the nip. This produces a nip taper with a constant load.

**Gap Winding**– Films that are relatively narrow, that can be wound at higher tensions and are wound at speeds generally less than 250 mpm (800 fpm) can be gap wound. Gap winding allows a small amount of air to be wound into the roll to prevent deforming webs that have high caliper band areas. To successfully control roll hardness when gap winding, the lay-on roll must move to maintain a small but consistent gap between it and the surface of the winding roll. Roll density is controlled through torque, which is the web tension, applied through the spindle drive.

**Torque Winding Principle** - Torque winding is the force induced through the center of the winding roll which is transmitted through the web layers & tightens the inner wraps of film. This torque is used to produce the web tension on center winders. With these types of winders; 'tension' and 'torque' are the same winding principle. However, when the pressure roll is driven to control the web's tension, then the torque induced through the center of the roll can be independently controlled to control the winding roll's hardness profile.



### Nip from Lay-on Roll



### Nip of Winding Roll into Drum

#### Film Winding Processes

There are three basic winding processes used for winding of film webs. These are center winding, surface winding and combination center-surface winding. Each process uses one or more of the TNT winding principles to build roll hardness.

**Center winding** – A center winder could be a gap winder where only tension is used to control the roll's hardness. A center winder could also incorporate a lay-on or pressure roll. This winder would use both tension and nip to control the roll's hardness. With a center winding process, the spindle torque through the center of the roll provides the web tension.

An advantage of center winding is that this process can wind softer rolls. This type of turret winder can provide quick indexing and fast cycle times. The disadvantage of center winding of film is the limitation of maximum roll diameter due to the torque applied through the layers of film. Also, center winders have a higher probability of generating scrap during roll changes.

**Turret center winders are:**

- Best for winding soft rolls (i.e. films with gauge bands)
- Best for winding film with high tack
- Best for winding small diameter rolls
- Easily designed for dual direction winding
- Able to provide adhesiveless transfers

**Surface winding** – When surface winding elastic films, web tension is the dominant winding principle. When surface winding inelastic materials, nip is the dominant winding principle. Surface type film winders use a driven winding drum. The winding rolls are loaded against the drum and are surface wound.

The advantage of surface winding is that the web tension is not supplied from torque being applied through the layers of film wrapped into the roll. The disadvantage of surface winding of film is that air cannot be wound into the roll to minimize gauge bands and roll blocking problems. Other disadvantages of drum surface winders are: The web tension is not controlled through the wound layers and therefore, the winding tension is only known prior to the drum. A drum type surface winder provides only single direction winding (unless on a turntable). Tape or glue on cores is required for automatic transfers.

**Drum surface winders are:**

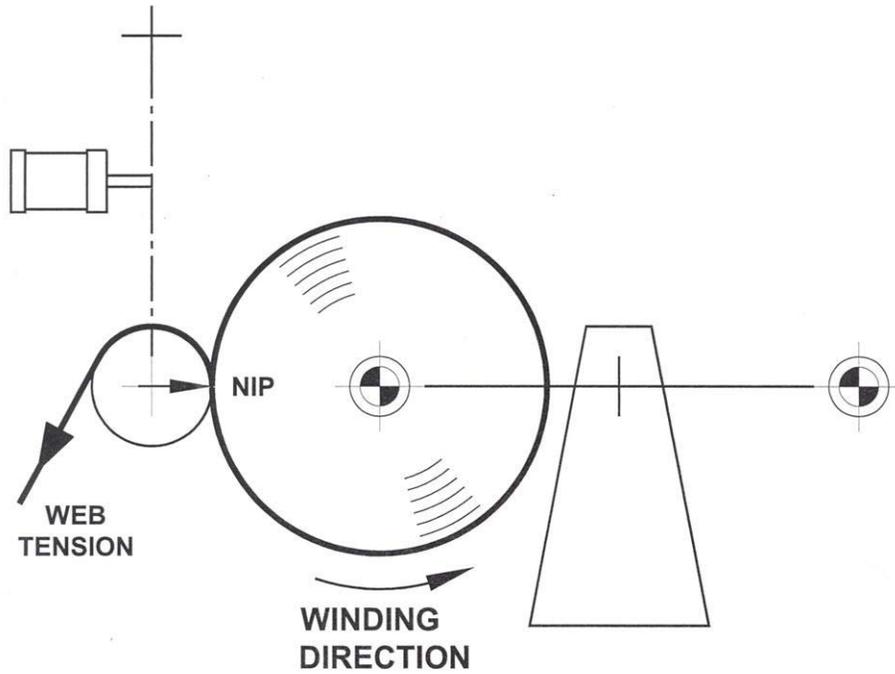
- Best for winding hard rolls (i.e. protective films)
- Best utilization of space and horsepower
- Best for winding very large diameter rolls
- Best for minimizing waste during transfers
- Less expensive
  - ✓ Less equipment
  - ✓ Single & smaller winding drive

**Center-Surface Winding** –A center-surface winder uses both center winding and surface winding processes. Center-surface winding uses all three of the **TNT** winding principles. The web **Tension** is controlled by the surface drive connected to the lay-on or pressure roll to optimize the slitting and web spreading processes. The feedback from the web tension load cells trims this drive to control the web tension. The web tension is held constant during the winding operation. The lay-on roll loading applied to the winding roll controls the **Nip**. Ideally the web wraps the lay-on roll 180° with the resultant tension vector 90° to the nip. This will provide maximum tension isolation between web and winding tension and a configuration where the web tension does not affect the nip loading. The **Torque** from the center drive is programmed to produce the desired in-wound tension for the roll hardness profile desired.

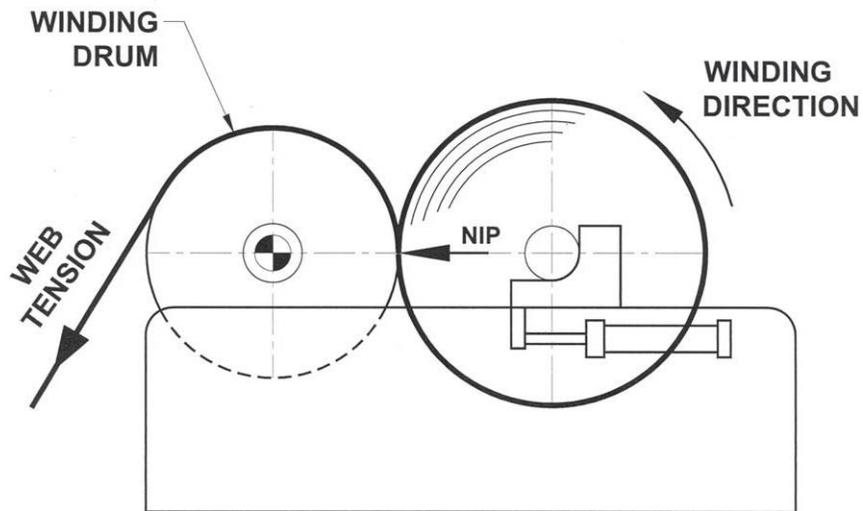
The advantage of center-surface winding is that the winding tension can be independently controlled from the web tension. The disadvantage of center-surface winding is that the winding equipment is more expensive and more complex to operate.

**Center-surface winders are:**

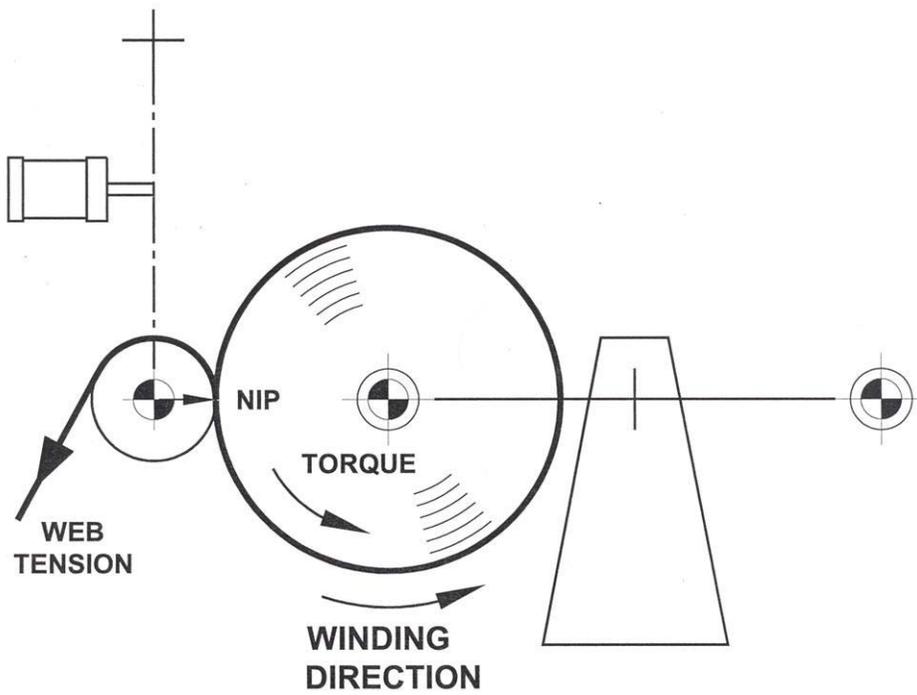
- Best for winding high slip films to larger diameters
- Best for slitting and winding extensible films to larger diameters
- Best for ability to significantly taper in-wound tension without affecting the width of the film
- Able to supply in-wound tension without stretching the web over caliper bands



**Tension – Nip Principles On A Center Turret Winder**



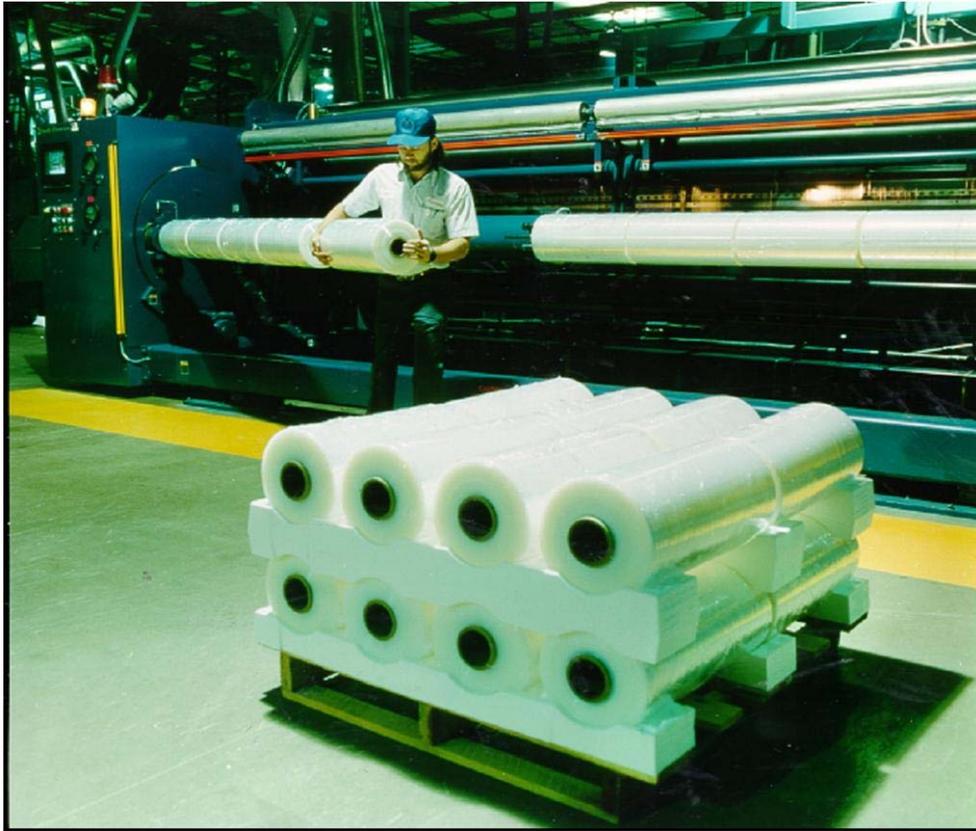
**Tension - Nip Principles On A Drum Surface Winder**



**Tension-Nip-Torque Principles**  
**On A Center-Surface Turret Winder**



**Drum Winder on a Nonwoven Coating Line**



**Center Winder on a Cast Film Line**



**Dual Turret Winder on a Blown Film Line**

## **Measuring Roll Hardness**

Winding of film is often referred to as an “Art”. This is because the setting and programming of the Tension, Nip and Torque will vary depending on:

- The type and design of the winder
- The type of web material being wound
- The width of the rolls being wound
- The speed of the winding operation

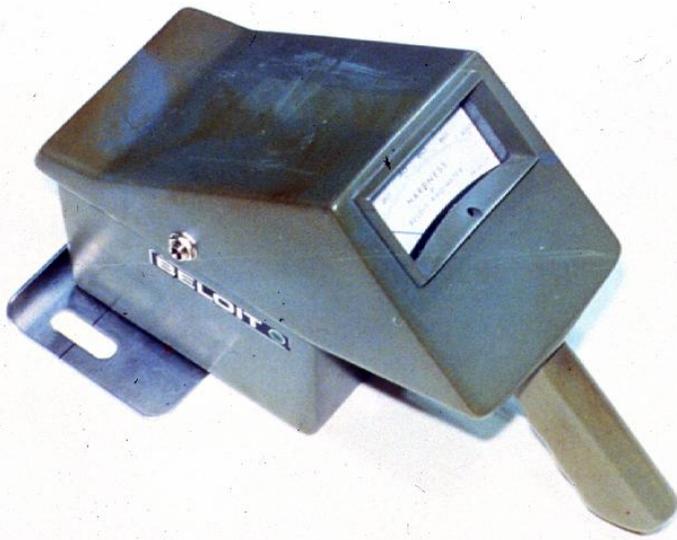
Not only will the same settings provide different roll hardness with the variations above, also different film products and different end use applications will vary the roll hardness and profile desired. However, after the hardness profile has been established, this hardness must be reproducible on a consistent basis. To accomplish controlled roll hardness, measuring devices must be available to the winder operators. With these devices, an operator can check roll hardness and make adjustments accordingly to insure that the roll hardness is within the acceptable range for the product.

To measure the roll hardness across the outer surface of the roll, it is suggested that either a ‘Rhometer’ or a ‘PAROtester’ be used. Both of these are ‘impact’ based devices for measuring a ‘relative roll hardness’ on a relative scale. The Rhometer is an instrument that measures the peak deceleration of a small hammer as it strikes the outer surface of the roll. The PAROtester is similar to the Schmidt hammer. The Schmidt Hammer was developed for concrete hardness testing and has been borrowed for use on roll hardness testing. The PAROtester was developed specifically for evaluation of hardness of rolled-up paper, foils and films. The PAROtester is considerably more sensitive, has less impact energy and is less operator dependant due to its more defined direction of impact than the Schmidt hammer.

A ‘Smith meter’ is an instrument that can be used to measure the hardness profile from the core to the outer wraps of the roll. The Smith meter measures the penetration of a small needle as it is inserted in-between the wraps of the web along the roll’s sides.

With computerized data acquisition systems now available, such as the ‘Black- Clawson AccuWind’ system, it is now possible to calculate the Roll Density Factor (RDF) and plot the relative roll density from core to full roll as the roll winds. These systems compare the actual winding roll’s diameter with the theoretical diameter and plot the ratio as a function of the winding roll’s diameter. The RDF is displayed to the operator on the Operator Interface Terminal (OIT) at the winder console.

The operator needs to have a means available on the winder to measure the roll hardness for both core to full roll and across the roll.



Rhometer



PAROtester

*Hardness Devices for Measuring Roll Hardness Across Roll*



Smith Needle



AccuWind Roll Density Curve

*Hardness Devices for Measuring Roll Hardness  
From Core to Full Roll*

## **Visual Roll Defects**

So far, we have concentrated on the importance of roll hardness and how it is produced and measured. We have discussed roll defects that are caused by roll hardness which are:

- Out-of-round rolls
- Roll blocking
- Gauge bands or Hard spots
- Baggy areas in the film
- Corrugations or rope marks
- Dished and telescoped rolls
- Starred rolls

Other defects that need to be avoided in order to consistently wind good rolls of flexible packaging films include:

- Poor starts
- Core offsets
- Splices
- Offsets and interweaving
- Trim wound into rolls
- Slitter rings
- Other slitter defects such as:
  - ✓ Excessive slitter dust
  - ✓ Nicked blades
  - ✓ Scalloped edges
  - ✓ High edges

Properly defining all of the above roll and web defects and addressing the possible causes and remedies is far beyond the allowable pages of this article. The book '*Roll and Web Defect Terminology*' -2<sup>nd</sup> edition by TAPPI PRESS describes defects commonly found in paper, film and non-woven webs and wound rolls. Please see this book or its subsequent later revisions for more information.

## **In Conclusion**

Winding good rolls of flexible packaging film is the challenge that every operator faces. Consistently winding good rolls depends on the consistency of bringing good film to the winding operation. A winder operator's job is not to camouflage poor quality flexible packaging film products into shippable rolls. His or her responsibility is to handle films with slight imperfections and to produce quality rolls that will run without problems on the downstream customer's process, and produce high quality products for their customers. I hope that the information presented will help in meeting that challenge.

## **References**

1. Smith, R. Duane, *The Challenges of Winding Flexible Packaging Film*”, Society of Plastic Engineer’s ANTEC Conference, Moscone Convention Center, San Francisco, CA, May 2002
2. Smith, R. Duane, *The Art of Winding Good Rolls*, Paper Film & Foil Converter, August, 01 pp 46-53
3. Smith, R. Duane (Editor), *Roll and Web Defect Terminology-2nd edition*, TAPPI PRESS, Atlanta, 2007
4. Roisum, D.R., *The Mechanics of Winding*, TAPPI PRESS, Atlanta, 1994
5. Seidel, K.L. *Practical Approach to Winding Principles*, TAPPI Winding Short Course, 1987

www.tappiplace.org

**PLACE**



POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

**2007 PLACE  
Conference**

**September 16-20**

**St Louis, MO**

# Challenges of WINDING FLEXIBLE PACKAGING FILMS

Presented by:

**R Duane Smith**

Product Manager / Specialty Winding

**Black Clawson – Egan Converting**

**Machinery / Davis Standard LLC**

## *Challenges in Winding Flexible Film*

**Every flexible packaging film producer is faced with the challenge of consistently producing quality rolls of film products. This presentation is a tutorial on film winding to help you overcome this challenge.**

*We will be covering a lot of information*

# ***Goal of this Presentation***

That you will take back at least  
A few Gold Nuggets from the  
Information presented and  
Apply These to Improve the  
Productivity & Profitability  
Of Your Operation

# *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.

*Perfect Film* - There is No Such Animal !!

**Winding operations challenge is to wind film webs with Slight Imperfections and produce Quality Rolls that will run on Customer's processes without problems.**

*The Art of Winding Quality Rolls of  
Flexible Films*

**WHAT IS A  
GOOD Quality  
ROLL?**





# ***WHAT IS A Quality ROLL?***

## **FILM ROLLS MUST BE:**

- ***RIGHT SHAPE*** - ROUND AND PROPER WIDTH
- ***RIGHT SIZE*** - RIGHT DIAMETER OR LENGTH
- ***RIGHT CONSISTANCY*** - NOT TOO HARD  
NOT TOO SOFT
- ***LOOK GOOD*** - NO BLEMISHES OR  
VISUAL DEFECTS
- ***AROMA?*** - WIND *POOR QUALITY* ROLLS -  
SOMEONE WILL RAISE A STINK!!!

# ***Roll Hardness***

**The Critical Factor  
In Determining the  
Difference Between  
A Good Roll & A Bad Roll  
of Film Products**

# **ROLL DEFECTS DUE TO ROLL HARDNESS**

- ***OUT OF ROUND ROLLS***
- ***ROLL BLOCKING***
- ***RIDGES***
- ***BAGGY AREAS IN THE FILM***
- ***CORRUGATIONS OR  
ROPE MARKS IN FILM ROLLS***

*“Art of Winding” Article  
Paper Film & Foil Converting - August 2000*

# ***HOW TO ACHIEVE & MEASURE ROLL HARDNESS***

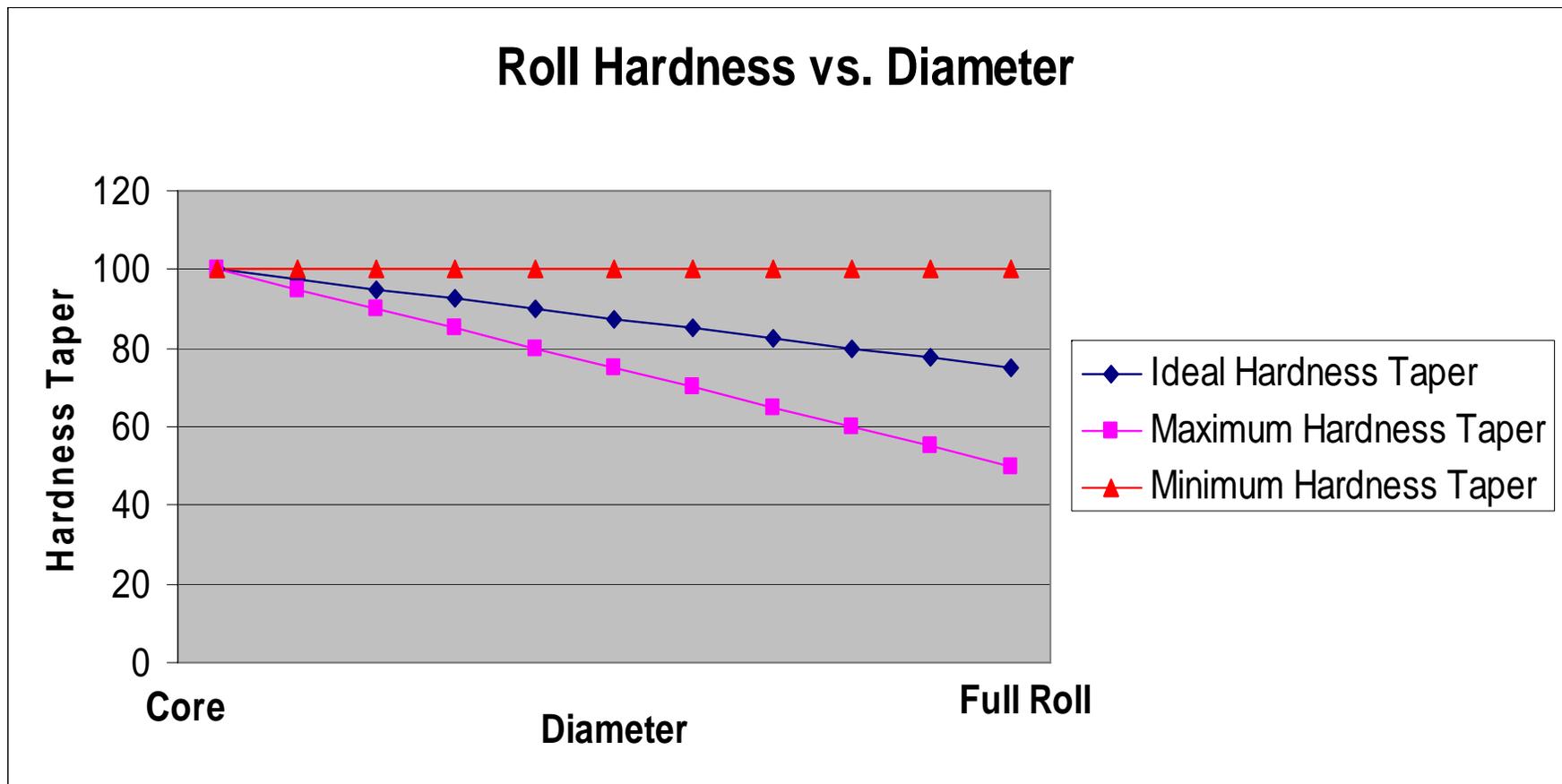
**AS ROLL WINDS - INWOUND TENSION OR RESIDUAL STRESSES BUILD UP INSIDE THE ROLL OF FILM**

**IF STRESSES BECOME GREATER AS ROLL WINDS LARGER - INNER WRAPS TOWARDS THE CORE WILL LOOSEN AND GO INTO COMPRESSION**

**THIS CAUSES ROLLS TO CONTAIN DEFECTS SUCH AS DISHING, BUCKLING &/or STARRING**

***ROLL HARDNESS MUST BE  
PROFILED TO PREVENT THIS!***

# ***ROLL HARDNESS PROFILES***



# ***Film Winding Process***

Three Winding Principles for  
Roll Hardness Control

## **TNT Winding Principles :**

*Tension* - The **WINDING WEB**  
Tension

*Nip* - The **NIP** of the Pressure Roll or  
Drum

*Torque* - The **TORQUE** from the  
Center Drive or Torque Drum

# *Tension Principle of TNT Winding*

*Elastic Films - Web Tension is  
Dominate Principle of Winding to  
Control Roll Hardness*

The more that you stretch

the web before winding -

The **harder** the wound rolls will be.

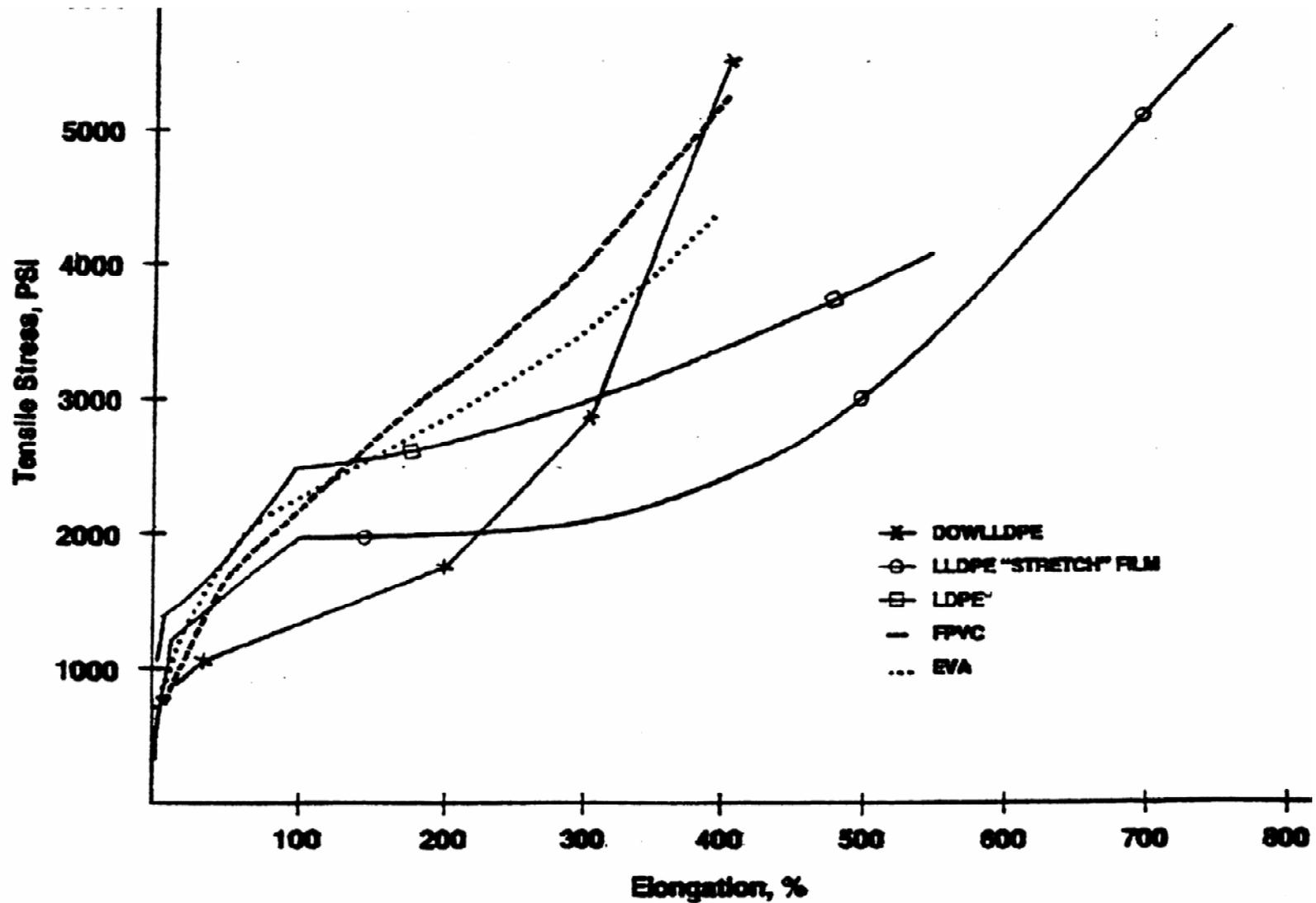
# *Tension Principle of Winding*

*How Do Determine  
the Maximum amount  
of Tension  
to Wind at ???*

# *Maximum Allowable Tension*

- Empirical data has shown that a tensile stress of **1.5%** of the Modulus of Elasticity can be applied without inducing significant permanent stresses.
- The Modulus of Elasticity shows a stress vs. strain relationship

# *Stress/Strain Curves for Film*

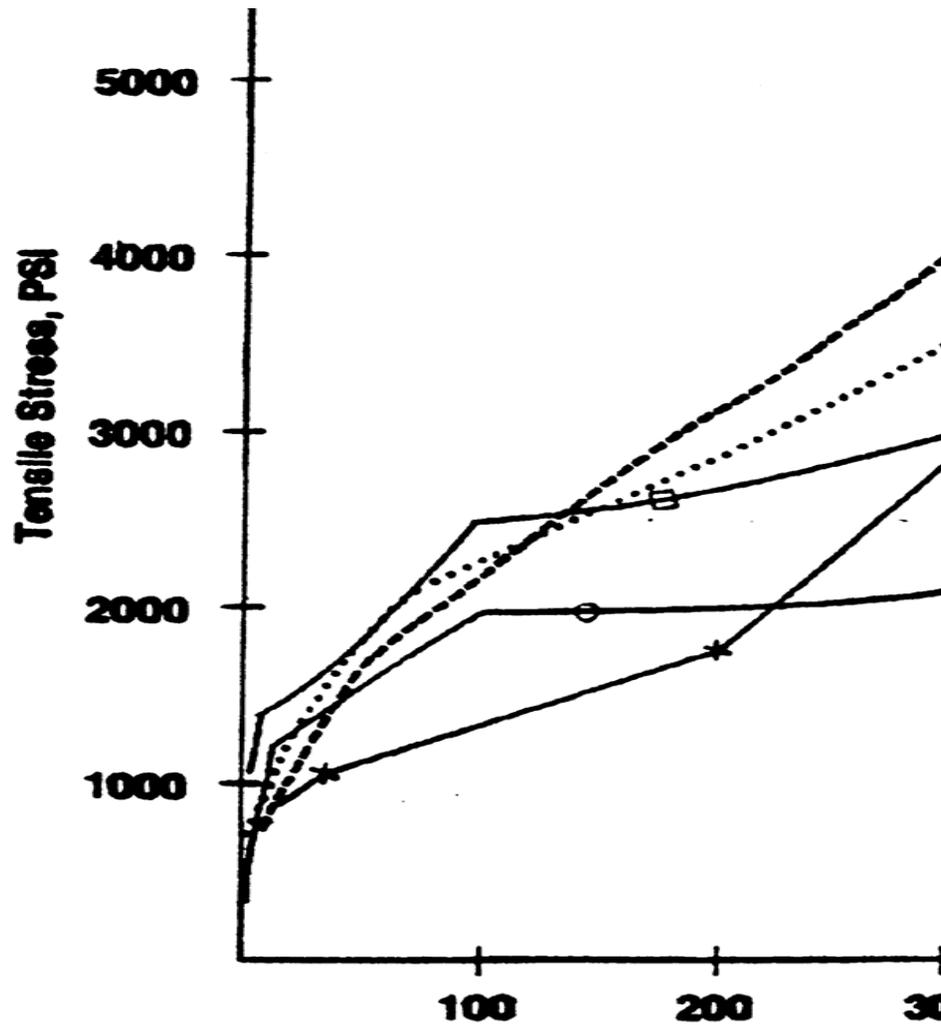


*Life is not easy for Plastic People*

# How to Determine the *Modulus of Elasticity of Plastics?*

A secant modulus of 1 or 2 % strain, can be used to determine a useable Elastic Modulus by extrapolating it linearly to 100%

# *Stress/Strain Curves for Film*



# *Tension Principle of Winding*

## **Modulus of Elasticity**

**Some typical secant moduli are:**

PVC(flexible)	350 - 560 kg/cm <sup>2</sup>	(5-8 kpsi)
LDPE	1,000 - 1,800 kg/cm <sup>2</sup>	(15-25 kpsi)
LLDPE	1,400 - 2,100 kg/cm <sup>2</sup>	(20-30 kpsi)
HDPE	8,400 - 14,000 kg/cm <sup>2</sup>	(120-200 kpsi)
BOPP	7,700 - 24,000 kg/cm <sup>2</sup>	(110-350 kpsi)
OPET	35,000 - 42,000 kg/cm <sup>2</sup>	(500-600 kpsi)

# How to Determine the Max Winding Tension?

## Metric Example:

Max. Tension for 50 micron (.05mm) LDPE

Using 1.5% of elastic modulus calculation

- Assume a modulus of 1,400 kg/cm<sup>2</sup> (LDPE)
  - 1.5% of 1,400 is  $.015 \times 1,400$  or 21 kg/cm<sup>2</sup>
- Then for a 1500mm wide x .05 mm thick web
  - $1500\text{mm} \times .05\text{mm} \times .21\text{kg/mm}^2 = 15\text{kg}$   
Max. allowable tension

**Try to keep web at or below this tension  
during processing**

# How to Determine the Max Winding Tension?

## English Example:

Max. Tension for 2 mil (.002") LDPE

Using 1.5% of elastic modulus calculation

- Assume a modulus of 20,000 psi (LDPE)
  - 1.5% of 20,000 is  $.015 \times 20,000$  or 300 psi
- Then for a 60" wide x .002" thick web
  - $60" \times .002" \times 300 \text{ \#/in}^2 = 36\#$

Max. allowable tension

**Try to keep web at or below this tension**  
**during processing**

# *Tension Principles of Winding*

## Taper Tension

- Reduce the tension smoothly as the roll diameter increases
  - 0 - 50% taper, 25% common
- Taper Tension reduces roll defects such as - Dishing, Buckling and Starring

# *Nip Principle of TNT Winding*

*Inelastic Films - Nip is  
Dominate Principle of Winding  
to Control Roll Hardness*

The more that nip load applied to the surface - the harder the wound rolls will be.

# **Nip of Winding Rolls :**

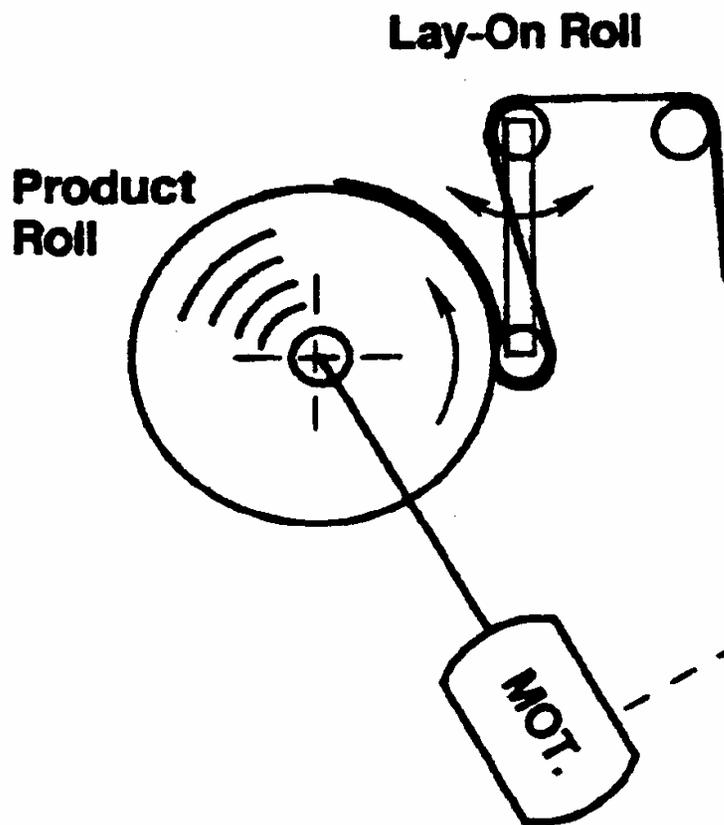
*-Removes the boundary layer of air following the Film.*

*-Adds Inwound Tension - The higher the nip, the harder the rolls.*

Challenge is:

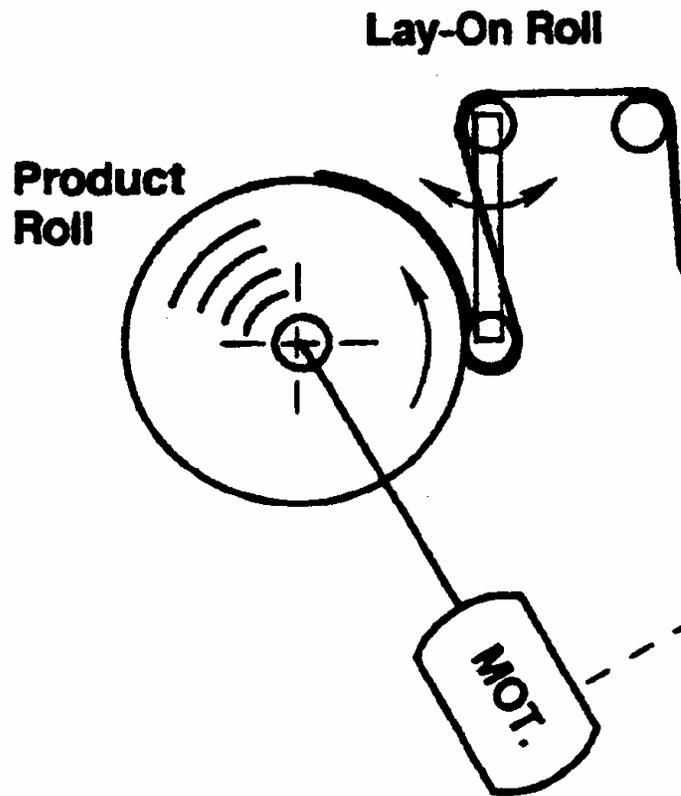
To have sufficient nip to remove the air, and wind hard & straight rolls without winding too much in-wound tension, to prevent blocking and deforming the web over caliper bands.

# *Nip Principles of Winding*



- The Nip must be applied where web enters the winding roll.
- The winding film's & lay-on roll's Weight and web Tension should not effect the Nip loading.

# *Nip Principles of Winding*



- The Nip Load should be tapered as roll winds to prevent starring and dishing. However,
- The larger winding the roll's dia, the more air is induced into the nip. This produces a Tapered Nip Loading with a constant Nip Pressure.

# **Gap Winding**

**Air sometimes wants to be wound into  
the winding roll of film to:**

- **Prevent blocking problems**
- **Prevent deforming the film that  
is wound too tightly over gauge bands**

**Lay-on Roll should follow the Winding  
Roll's Surface with a Small Controlled Gap**

# *Film Winding Process*

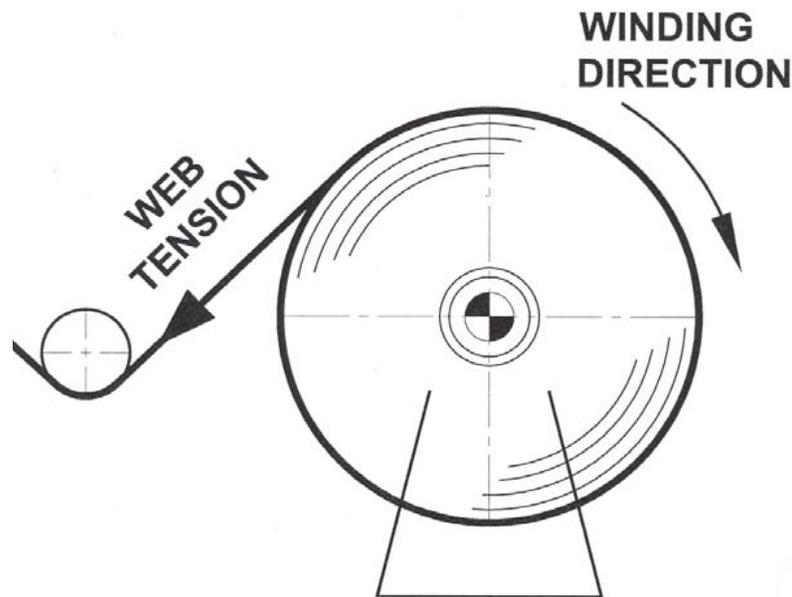
## *Basic types Film Winding Processes*

- **Center Winding**
- **Surface Winding**
- **Combination Center/Surface Winding**

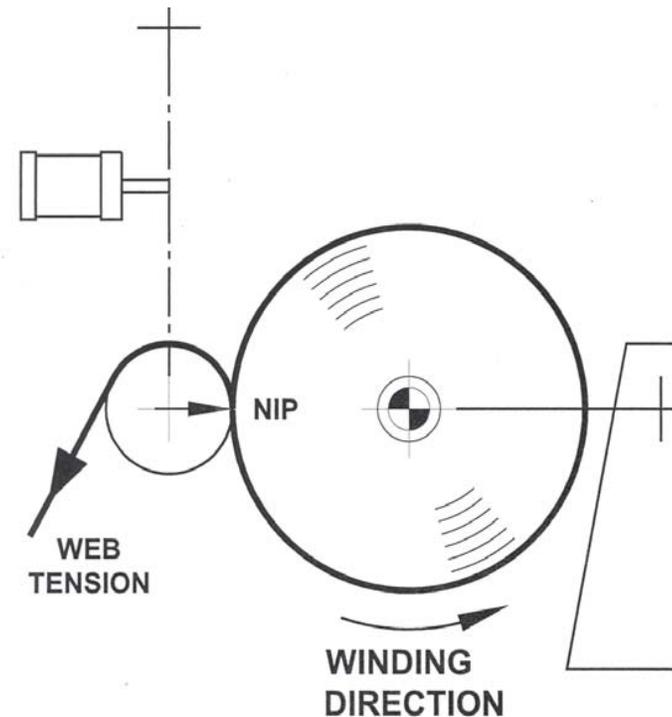
*EACH TYPE USES ONE OR MORE OF  
THE T.N.T. PRINCIPLES TO BUILD  
ROLL HARDNESS*

# ***CENTER TYPE WINDERS***

*Tension & Nip are Dominate Winding Principles*



**Pure Center Winder  
Tension Principle Only**



**Center Winder w/Lay-on Roll  
Tension plus Nip Principle**

# **Turret Center Winders**

**Gap Winding** - Use web Tension only.

(Web tension provided by spindle torque)

**Contact Winding** - Use web Tension and Nip to control roll hardness

**Advantages** - Can build softer rolls.

Quick indexing, fast cycle times.

**Disadvantages** - Limited maximum roll dia. due to torque applied thru layers.

Higher probability of scrap during roll changes.

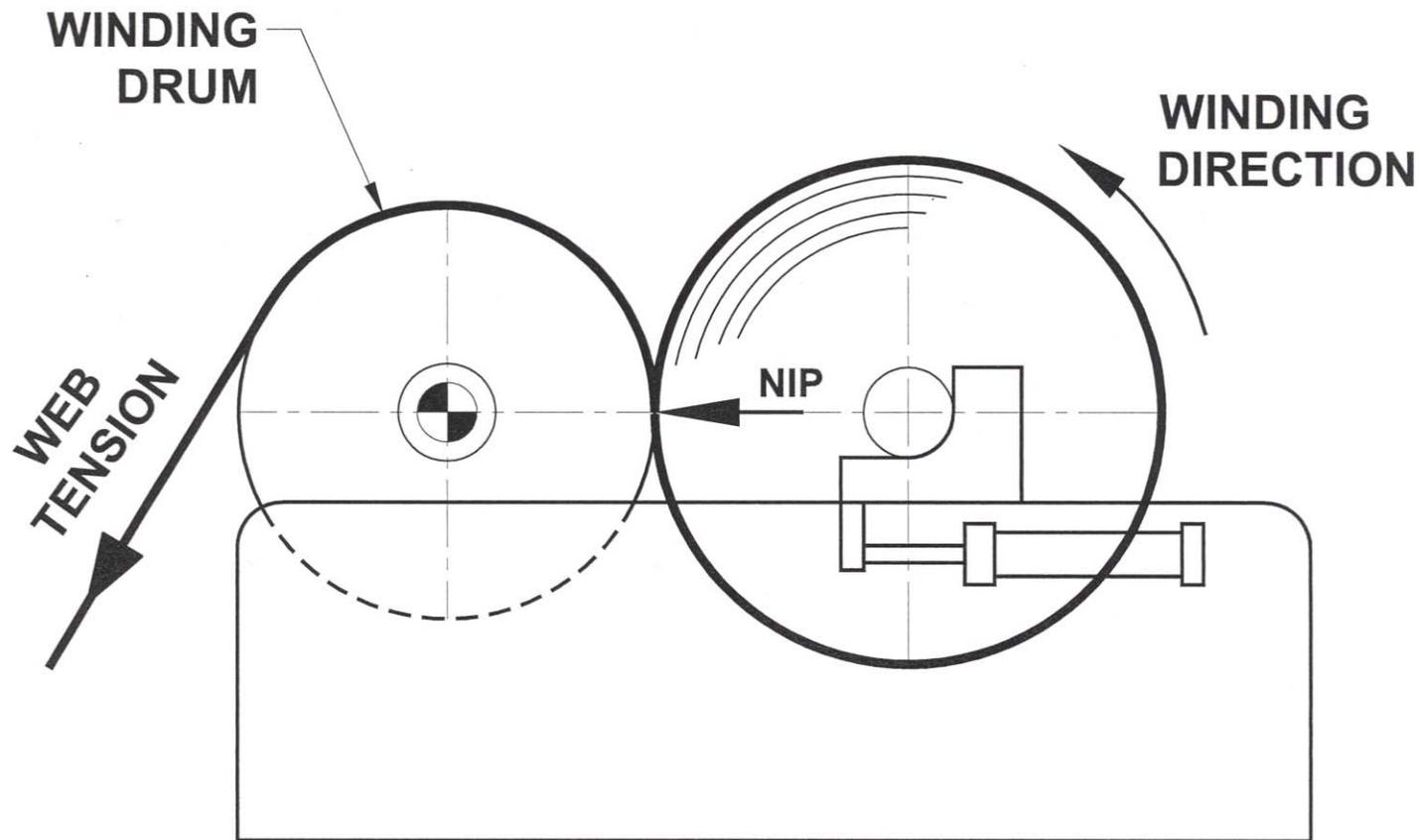
# *Turret Center Winders*

- Best for Winding Small Diameter Rolls
- Best for Winding Soft Rolls
  - i.e. - Films with Gauge Bands
- Best for Winding Film with High Tack
- Easily Provides Dual Direction Winding
- Can Provide Adhesiveless Transfers

# *Turret Center Winders*



# *Drum Surface Winders*



# *Drum Surface Winders*

Winding Elastic Materials -

**Web Tension** is dominate winding principle.

Winding Inelastic Materials -

**Nip** is dominate winding principle.

Advantage - Web Tension is not supplied from torque applied thru the roll.

Disadvantage - Can not wind air into roll to minimize gauge bands and roll blocking.

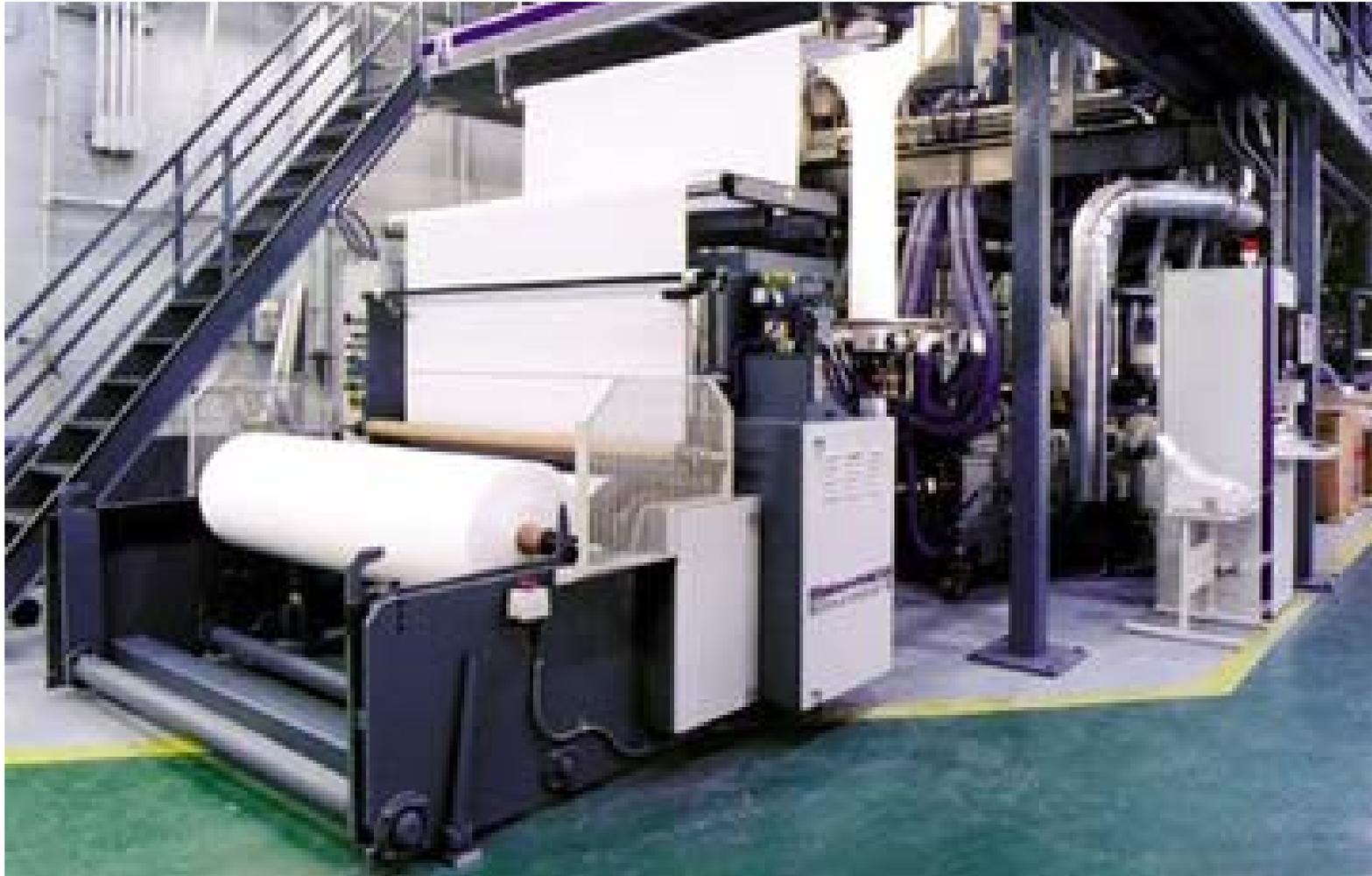
# *Drum Surface Winders*

- Best for Winding Very Large Diameter Rolls
- Best for Winding Hard Rolls  
i.e.. Protective Films
- Best Utilization of Space and Horsepower
- Minimum Waste During Transfers
- Less Expensive
  - Less Equipment
  - Single and Smaller Winding Drive

# **Drum Surface Winders**

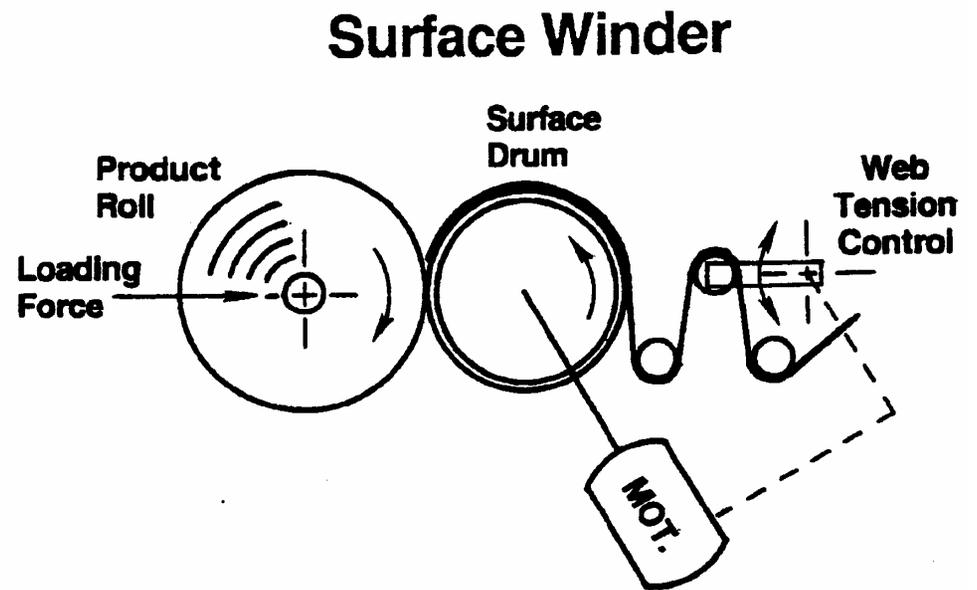
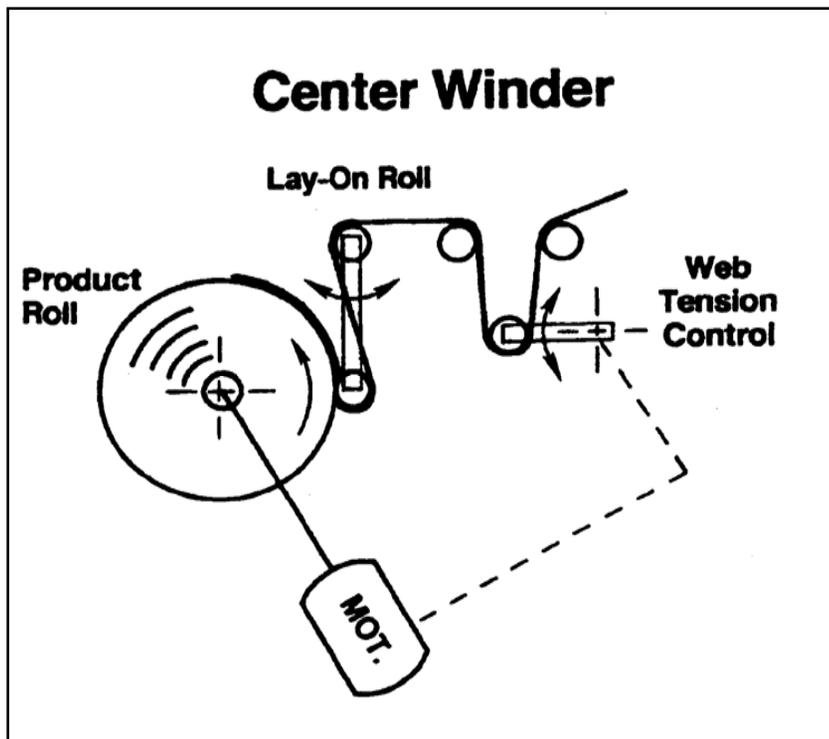
- + **In-line slitting with little waste**
- + **Thread up is simple and accessible**
- + **Winding of Large Dia. Rolls of Non-Extensible Film**
- **Tension is not controlled through the wound layers - tension is only known prior to the drum**
- **Single direction winding only** (Unless on turntable)
- **Requires tape or glue on core** for automatic transfers
- **No gap winding available**

# *Drum Surface Winders*

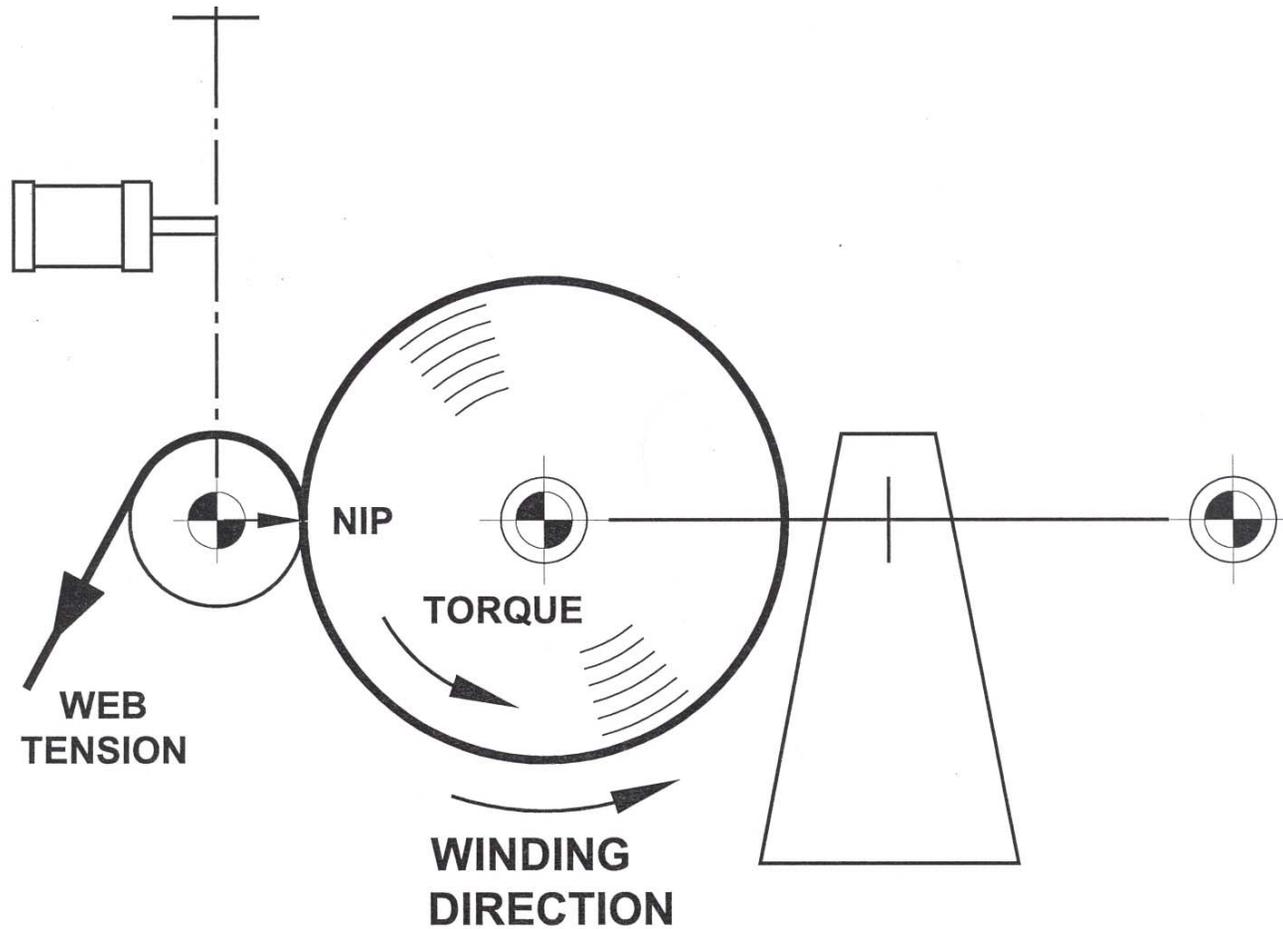


# *Center/Surface Winders:*

*Use Both Winding Methods*



# ***CENTER/SURFACE TYPE Turret WINDER***



# *Center/Surface Winders:*

Can use all three TNT principles -

Tension, which is used for slitting and spreading is controlled by Surface Drive.

Nip is controlled by the lay-on roll loading.

Torque from spindle drive controls roll hardness independent from web Tension.

*Advantages* - Can build larger rolls of slippery materials and can taper inwound tension without effecting neck-in of web width. Also can supply web tension w/o stretching web over gauge bands.

*Disadvantages*- More costly and complex.

# ***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***

Different Web Products and Different Applications Dictate Desired Roll Hardness

**HARDNESS PROFILE MUST BE REPRODUCED CONSISTANTLY**

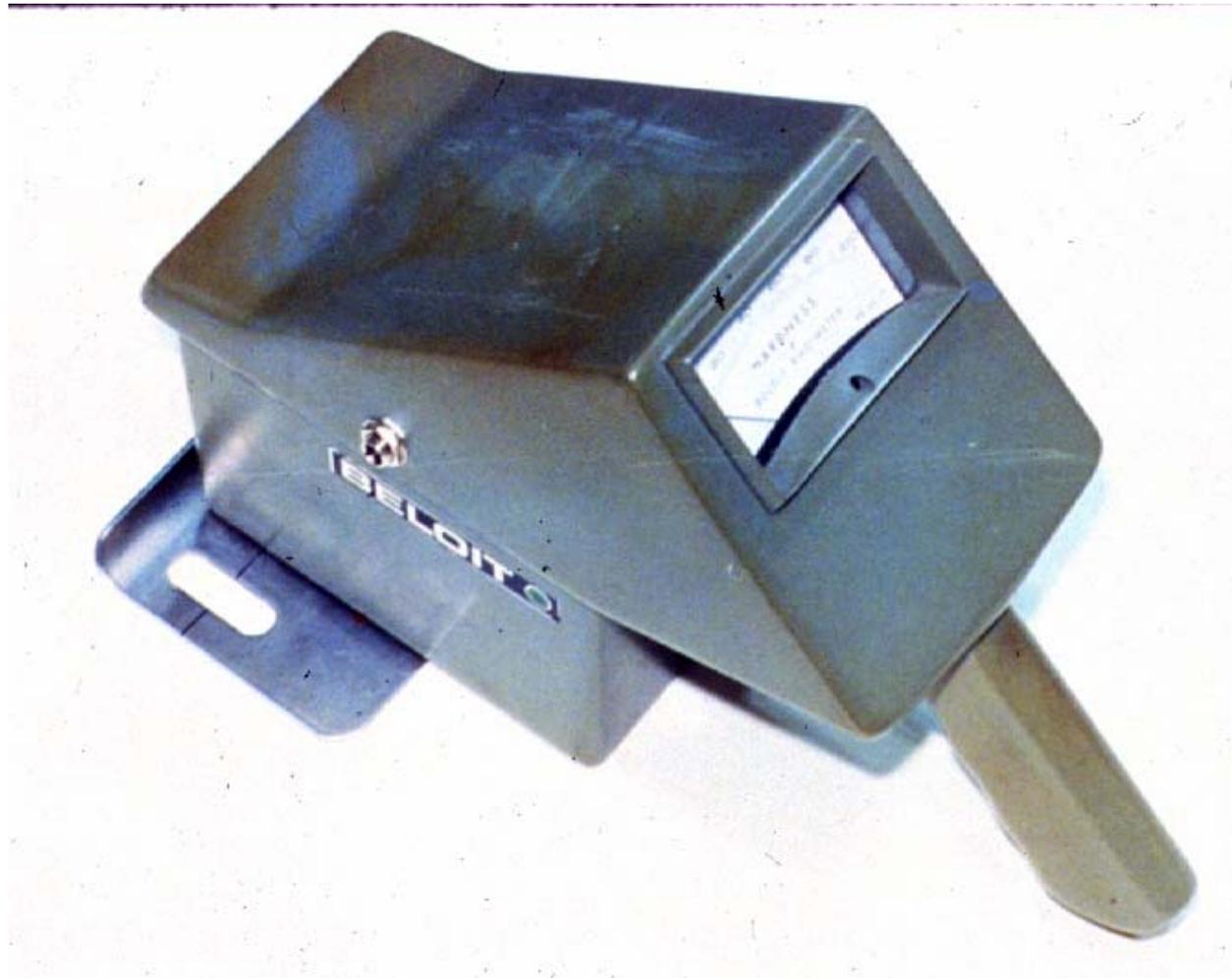
# ***MEASURING ROLL HARDNESS***

ROLL HARDNESS MEASURING DEVICES  
NEED TO BE AVAILABLE TO  
WINDER OPERATORS

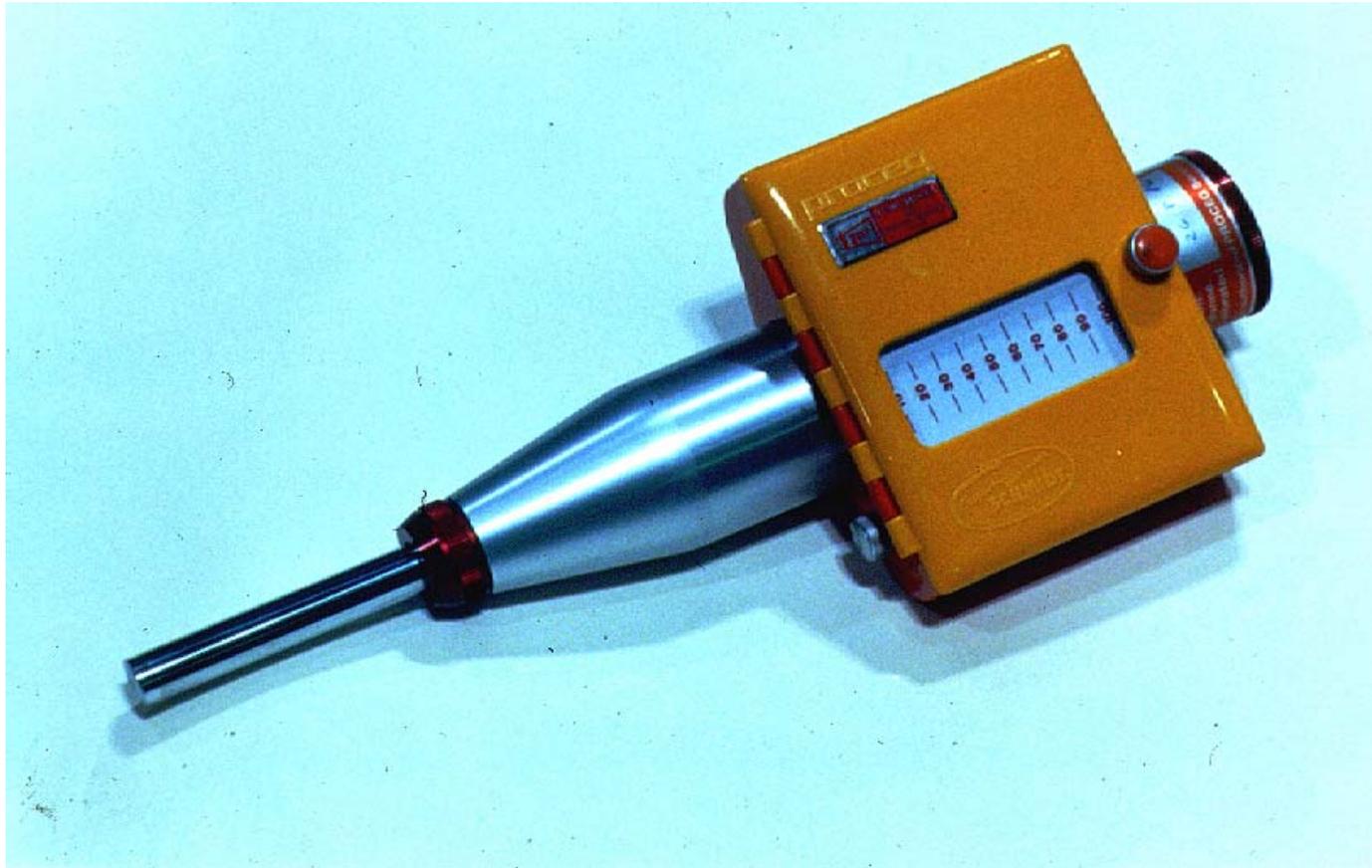
- ***RHOMETER -***  
Measures Hardness Across Outer Surface
- ***PAROtester (SCHMIDT HAMMER)***  
Measures Hardness Across Outer Surface
- ***SMITH NEEDLE -***  
Measures Hardness Core to Full Roll
- ***RDF Curve (Microprocessor Control System)***  
Measures Roll Density During Winding

# ***RHOMETER***

---



# ***SCHMIDT HAMMER***



# *PAROtester*



# *PAROtester*



# ***SMITH NEEDLE***



# *AccuWind ROLL DENSITY CURVES*



# *Film Winding Oscillation*

Films that contains high caliper or gauge bands can not be straight wound without forming ridges and deforming the web as it winds over these ridges.

The Winder and the Slitters must be moved back and forth or Oscillated to randomize these bands in the roll.

# Challenge of Oscillation Speed

Fast and Far Enough to

Randomize Bands Yet -

Slow Enough not to

Strain or Wrinkle Web

*Rule of Thumb -*

Max. Oscillation Speed =

2.5 cm per min. per 150 mpm Winding Speed

(1 inch per min. per 500 fpm Winding Speed)

**For Best Results**  
**Vary Oscillation Speed**  
**Proportional to Line Speed**

# **ROLL DEFECTS DUE TO ROLL HARDNESS**

- ***OUT OF ROUND ROLLS***
- ***ROLL BLOCKING***
- ***RIDGES***
- ***BAGGY AREAS IN THE FILM***
- ***CORRUGATIONS OR  
ROPE MARKS IN FILM ROLLS***

# ***OTHER VISAL DEFECTS TO AVOID FOR CONSISTANTLY 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**

# ***Roll and Web Defect Terminology***

## ***Tappi Press - 2<sup>nd</sup> Edition – 224 defects***

- **Sponsored by the PLACE Div. of TAPPI**
- **Illustrations, Causes and Remedies for 224 Defects with common Synonyms for each**
- **Expanded to 10 Chapters including chapters on:**
  - **Film Extrusion and Lamination Defects**
  - **Wrinkling**
  - **Web Handling Defects**
  - **Slitting Defects**
- **Written and Edited by 22 Industry Experts with over 500 years experience in Web Handling and Winding**  
**Plus 16 additional Contributing Editors**
- **Over 400 Pages of Information on Roll & Web Defects**

*Each of 224 defects*  
*Concise Information on:*

- **A description of the defect**
- **An illustration of the defect**
- **Lists the synonyms or “Also Known As” terms commonly used**
- **Cross references these synonyms in index**
- **Lists common causes of the defect**
- **Lists the common remedies of the defect**
- **Lists other sources of information published on the defect**

# ***In Conclusion***

**Winding good rolls of film is every**

**Winder Operator's challenge.**

**Consistently winding good rolls depends on the consistency of bringing good material to the winding operation.**

**A winder operator's job is not to camouflage poor quality web products into shippable rolls.**

**It is the Winder Operator's responsibility is to handle webs with slight imperfections and to produce quality rolls of film that will run on your Customer's process without problems and produce high quality products for their customers.**

***I hope that the information presented will help you meet this Challenge.***



*Questions?*

*Slide*

*Courtesy of  
Dr. David  
Roisum*

## *Practical Example*

# *Can't Wind Straight Sided Rolls*

Problem: When winding double sided silicon release PET film the rolls dish on the winder.

Solution: When trying to wind slippery grades to diameters over 4 times core OD, you need to be able to center/surface wind.

Then start winding with very high torque and taper torque to almost nothing by 4 times the core OD. Roll hardness profile is built using nip control of pressure roll on winding roll(s). Web tension is pulled by pressure roll speed control.

# Thank You !

## Challenges of WINDING FLEXIBLE PACKAGING FILMS

**Presented by:**  
**R Duane Smith**  
Product Manager / Specialty Winding  
Black Clawson - Egan  
Converting Machinery / Davis  
Standard LLC



*Please remember to turn  
in your evaluation sheet...*