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Guidelines for Selecting the Best Winding Process

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There is a lot of Science that goes into winding. The TNT winding principles are well established and have been proven and modeled at the Web Handling Research Center at OSU in Stillwater, OK. Yet determining which of these principles, or the proportional amount of each of these to use for proper winding of different types of materials under a specific set of conditions, is still considered an Art. This paper is a guide for selecting the best type of winder to use in order to consistently produce quality, defect-free rolls of web material. We will discuss the winding principles, how they are used on different types of winders, and present product parameters that each type of Winder is best suited for.

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:

T ension - The Winding Web Tension
N ip - The Nip of the Pressure Roll or Drum
T 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 used to control roll hardness. The more tension pulled and the more stretch put on the web before winding, the harder the wound rolls will ultimately be. The winding web tension is often determined empirically. However, the maximum amount of web tension can also be determined by using 10-25% of the materials tensile strength. 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.

Nip Principle of Winding

When winding inelastic webs, nip is the dominant principle of winding used 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 will be. The challenge for winding is to have sufficient nip to remove the air and wind hard, straight rolls without winding in too much in-wound tension in order to prevent roll blocking or deformation of 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 pressure 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 tapered nip pressure with a constant nip loading.

Torque Principle of Winding

Torque winding is the force induced through the center of the winding roll which is transmitted through the web layers & tightens the inner wraps. This torque is used to produce the web tension when center winding. Therefore, "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.

Winding of film is often referred to as an "Art". This is because the setting and programming of the **T**ension, **N**ip and **T**orque will vary depending on:

- The type and design of the winder
- The type of web material being wound
  - Thick / Thin
  - Extensible / Non-Extensible
  - Slippery / Sticky
- The width of the rolls being wound
- The speed of the winding operation

Winding Process

There are three basic winding processes used for winding of webs materials. 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 **T**ension 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 **T**ension and **N**ip 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 is the limitation of maximum roll diameter due to the torque applied through the layers of slippery webs. In addition, center winders have a higher probability of generating scrap during roll changes.

Turret center winders are:

- Best for winding soft rolls (i.e. webs 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 materials, 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.

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. (See Figure #1) Center-surface winding uses all three of the **T.N.T.** winding principles. The web **T**ension 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 constant web tension. during the winding operation.

The lay-on roll loading applied to the winding roll controls the **N**ip. The **T**orque 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. For high tension applications, center-surface winders can share the tension horsepower requirements to allow small center drives. 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

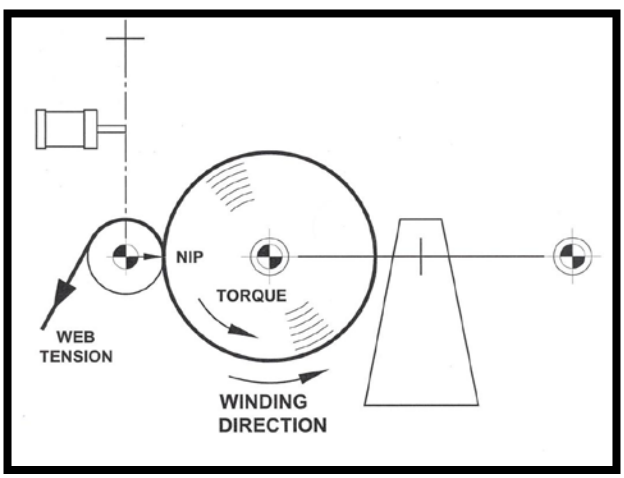

Figure 1: Tension-Nip-Torque Principles on a Center-Surface Turret Winder

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**
Thick Webs wound to Large Diameters	**2, 3**
Extensible “stretchy” Webs - Large Dia.	**2**
Non-Extensible Webs - Thin, Small Dia.	**1**
High Coefficient “Sticky” Materials	**1**
Low Coefficient “Slippery” Materials	**3**
Inline Slitting in Multiple Webs	**3**