THE MECHANICS OF TENSION CONTROL

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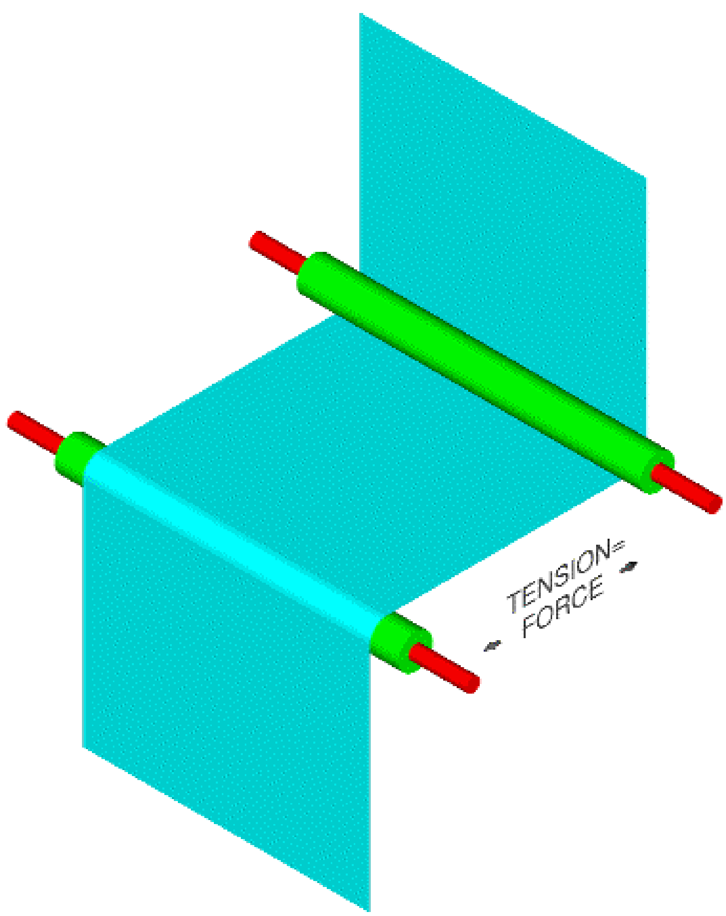
Introduction

This presentation is a basic tutorial in the mechanics of web tension control. We will discuss:

1) What is tension?
2) Why is tension important to me?
3) Where is tension control important in the process?
4) How do tension controls work?
5) What is the difference between closed loop and open loop tension controls?

What is tension?

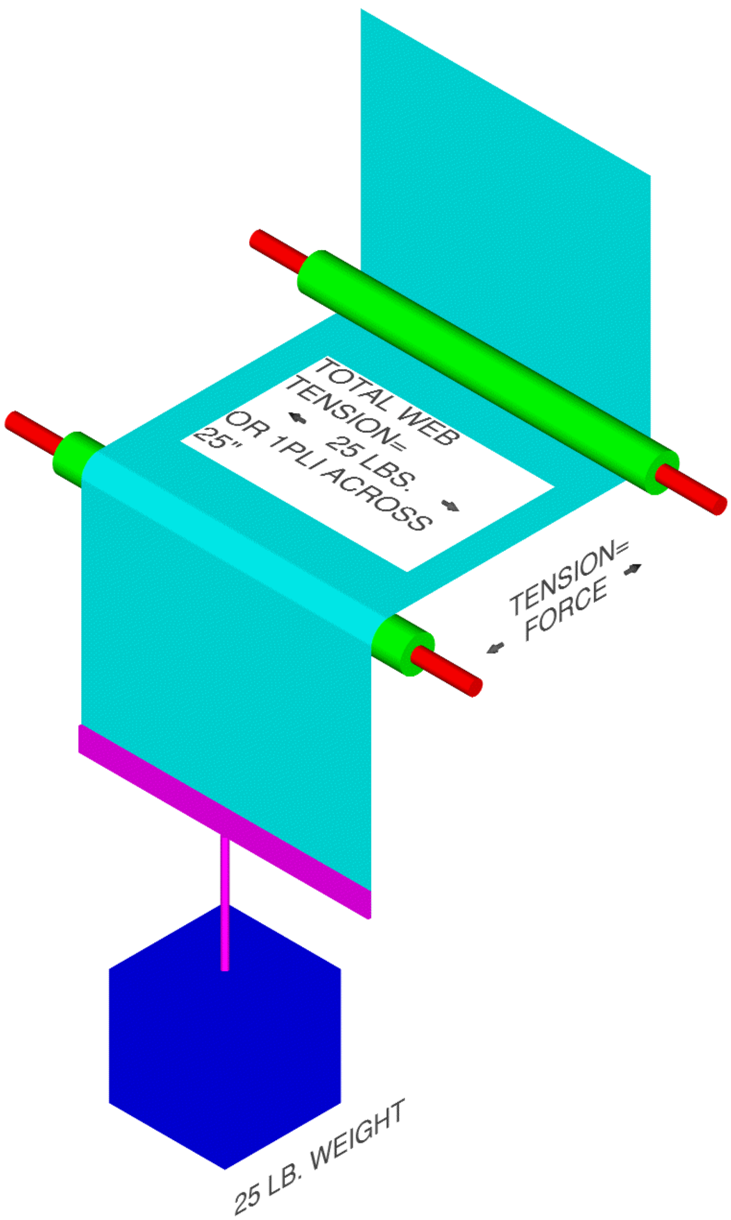
For the purpose of this presentation, tension is defined as the force applied to a continuous web of material in the machine direction.



Typically, tension is measured in PLI (Pounds per Linear Inch) in the US. If you know PLI and you want to know total tension applied to the web, multiply PLI times the width of the material in inches. If you know total pounds of tension applied to the web and you want to know PLI, divide the total pounds of tension across the web by the width of the web in inches.

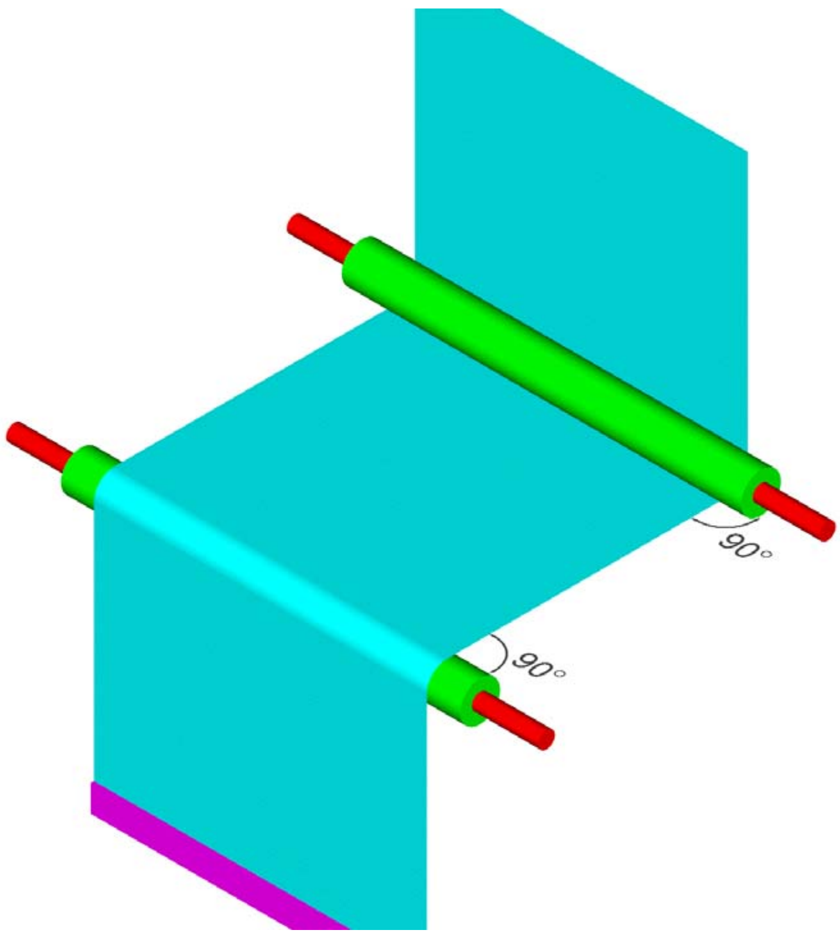
- PLI (Pounds per Linear Inch) = total pounds of tension / web width in inches
- Total pounds of tension = PLI X web width in inches

The tension applied to a web can be described as the webs tautness as if you hung a weight off the edge of the web. The tension on the web would be equal to the weight in pounds. PLI would be equal to the weight in pounds divided by the web width in inches.

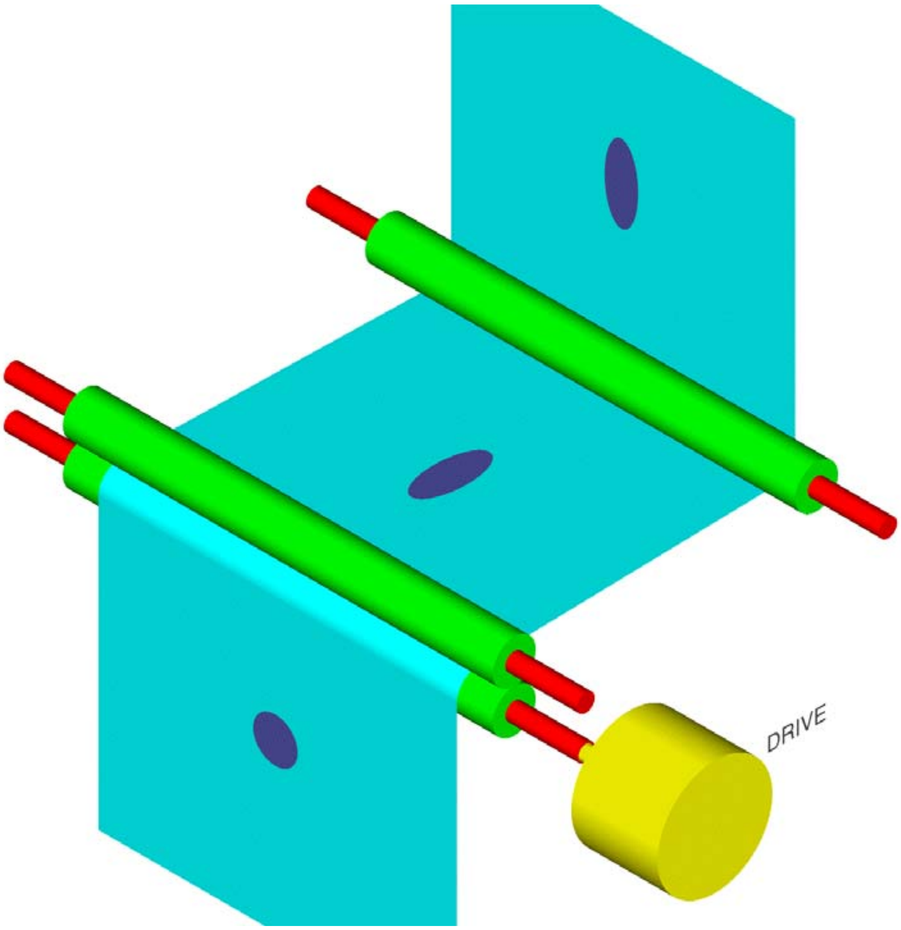


Why is tension important to me?

- It is impossible to control your web without proper tension being applied to it. The web must be "in traction" with all machine idler rolls and driven rolls to ensure proper web handling and control.
- The web handling principal states a web will seek to align itself perpendicular to an idler or driven roll. This web handling principal is applied to route webs through processes with parallel idler rolls and driven rolls. It is applied when web guides are used to steer webs. And it is also applied in many wrinkle removal devices. **However, the web handling principal does not apply to webs that are not in traction with idler or driven rolls.** In other words if the web slips over the face of an idler or driven roll it can wander from side to side or if the web slips on web guiding idler rolls it will not move where the web guide attempts to steer it. Tension must be applied to webs to keep them in traction with idler and driven rolls.

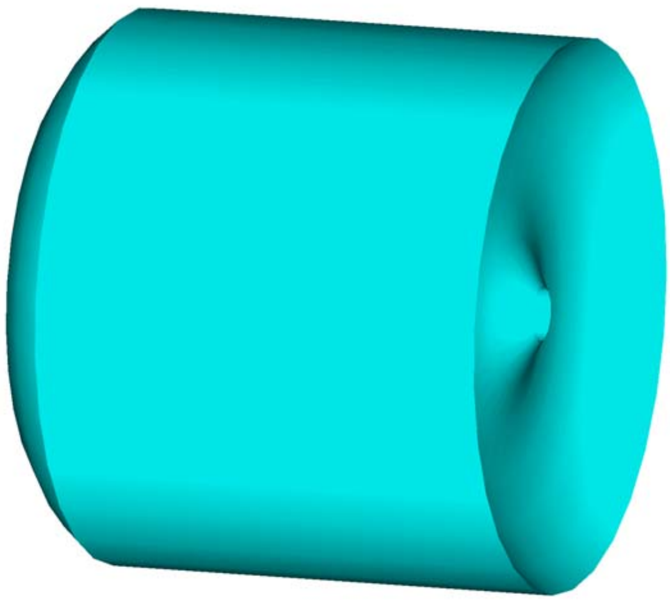


- All webs stretch in the machine direction as tension is applied to them. It is important to apply proper tension to a web so that it can be handled through the machine and processes without over-stretching.

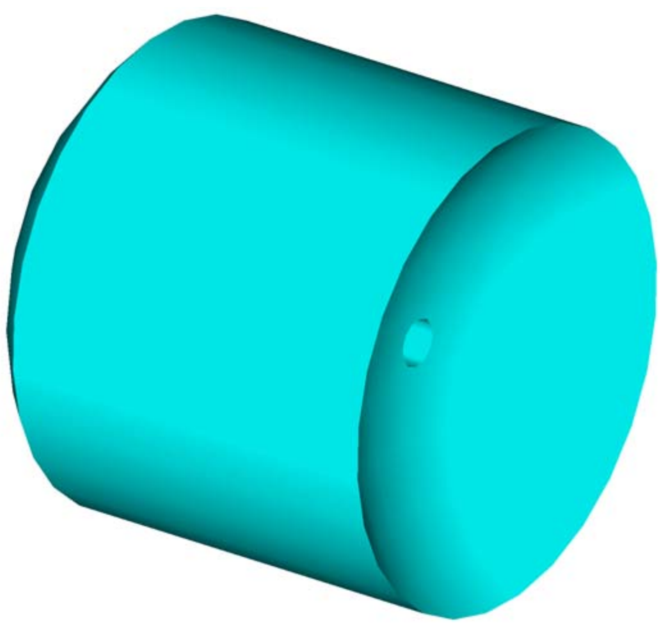


EXAMPLE OF EFFECTS OF WEB STRETCHING

- It is impossible to unwind rolls into a process without proper tension control at the unwind station. Telescoping, “dished” rolls, wrinkles and even web breaks will occur when tension is not controlled at the unwind station.
- It is impossible to rewind rolls from a process without proper tension control at the rewind station. Telescoping, “dished” rolls, wrinkles and even web breaks will occur when tension is not controlled at the rewind station.

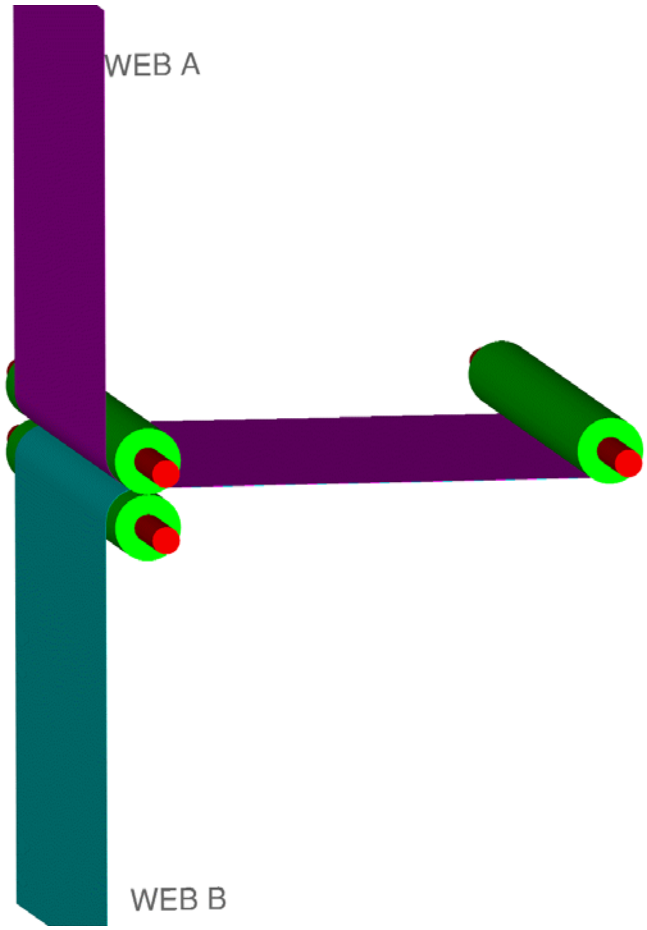


EXAMPLE OF A “DISHED ROLL”

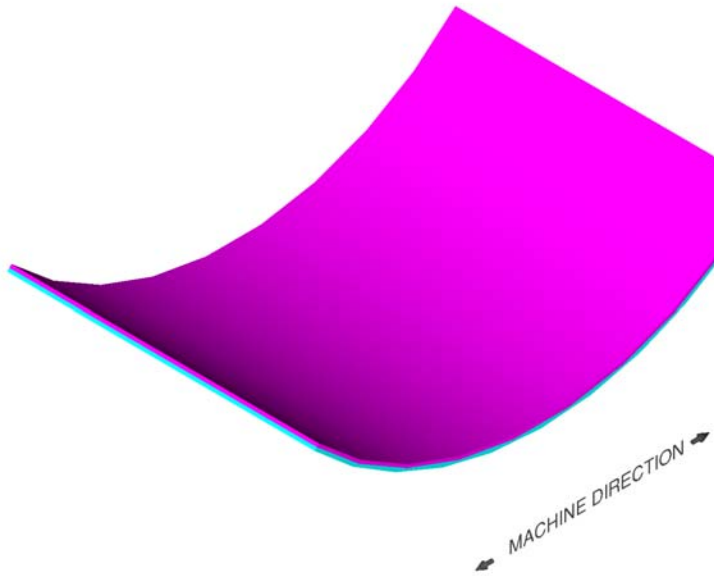


EXAMPLE OF A TELESCOPED ROLL

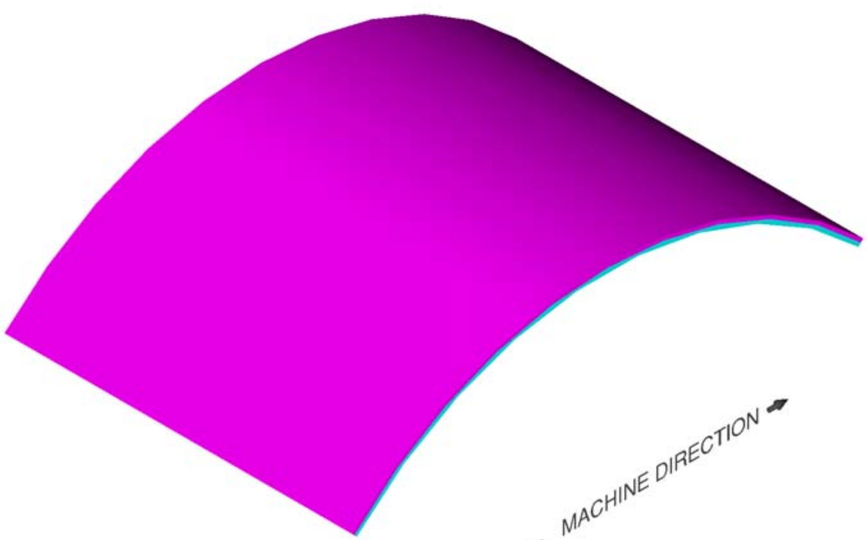
- Many converting operations require proper registration to print or die cut stations. Proper tension control is essential to controlling print to print or die cut registration.
- Laminating operations require layers to be laminated with proper tensions to avoid web curl.



EXAMPLE OF LAMINATING OPERATION



EXAMPLE OF WEB CURL IN THE MACHINE DIRECTION IF THE TENSION IN "WEB A" (TOP SUBSTRATE) IS GREATER THAN "WEB B" (BOTTOM SUBSTRATE). THIS EXAMPLE IS A RELAXED SECTION OF THE WEB AFTER IT IS LAMINATED.

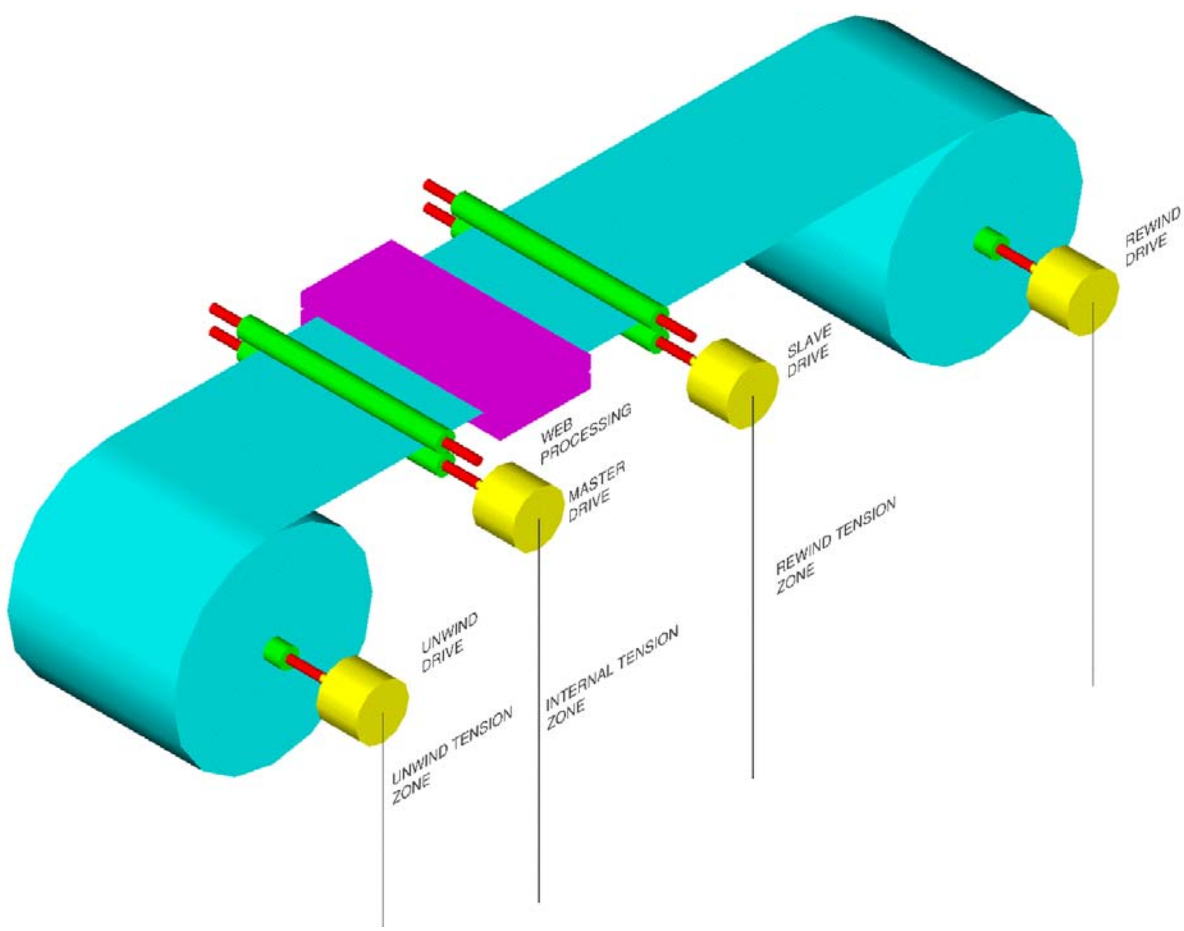


EXAMPLE OF WEB CURL IN THE MACHINE DIRECTION IF THE TENSION IN "WEB A" (TOP SUBSTRATE) IS LESS THAN "WEB B"(BOTTOM SUBSTRATE). THIS EXAMPLE IS A RELAXED SECTION OF THE WEB AFTER IT IS LAMINATED.

- Slitting operations require proper slit position, which is a function of tension and web guiding.
- When tension is too high webs will stretch in the machine direction and compress in the cross machine direction. This narrowing of the web width can cause wrinkles to occur.
- When tension is too low webs will shrink in the machine direction and web width will widen in the cross machine direction. This widening of the web width can cause wrinkles to occur.

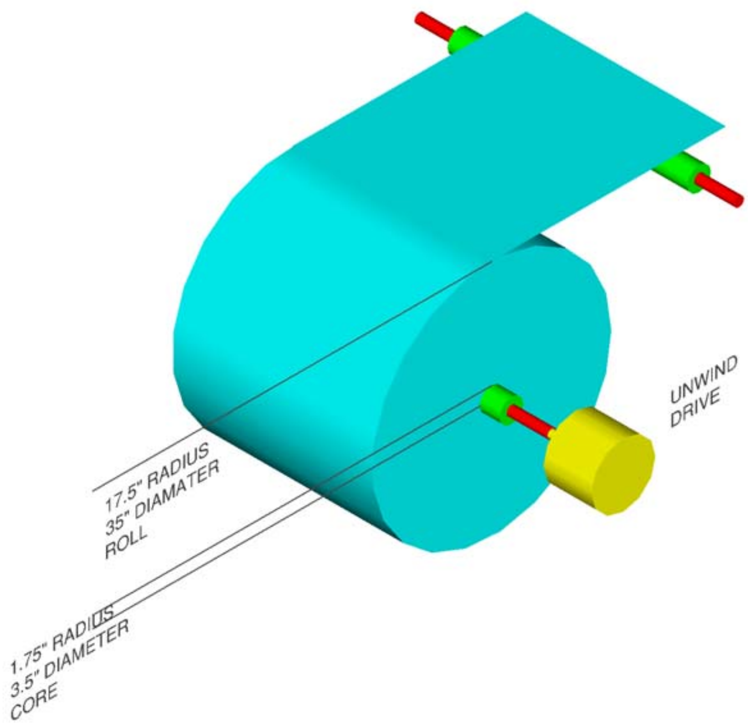
<u>Where is tension control important in the process?</u>

Most converting applications include three types of tension zones – unwind, internal and rewind. Each zone must be controlled independently. Multiple zones of each type are common in many converting applications; however, they normally are categorized as unwind, internal or rewind.



Each tension zone is very unique and must be controlled independently. Since independent tension controls are used in each zone, each zone may have its own tension level. This means, for example, tension in the unwind zone may be 1 PLI then increase to 2 PLI in the internal zone then decrease to 1.5 PLI in the rewind zone.

Torque required to provide a certain level of tension to a web is total tension measured across the web times roll radius. This means the torque driving the unwind shaft must **decrease** at a linear ratio, relative to roll diameter, as an unwind roll decreases in size, through a machine run, to keep tension constant. Conversely, the torque driving the rewind shaft must **increase** at a linear ratio, relative to roll diameter, as a rewind roll increases in size, through a machine run, to keep tension constant. Tension in the unwind and rewind zones is very dynamic. Roll diameters are constantly changing, so torque and speed must be constantly adjusted relative to changing roll diameters. Tension and speed in the internal zones is much more stable since roll diameters in these zones does not change. However, some control is required to set and maintain desired levels. Web defects, splices, desired machine speeds, machine defects and other variables will effect tension in the internal zones.

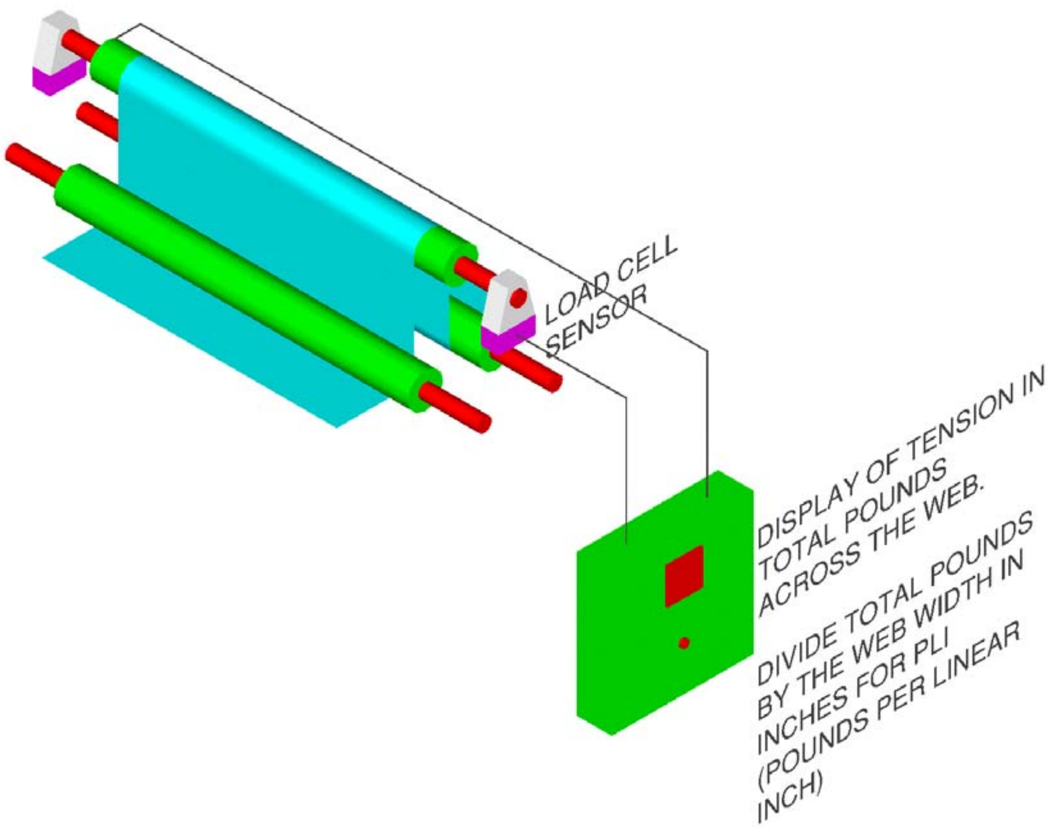


Remember the equation of torque = tension x radius is linear, so torque must be decreased (for unwinds) and increased (for rewinds) at a linear rate relative to roll radius. For example, if you start with a 17.5 inch roll radius (35 inch diameter) and unwind down to a 1.75 inch core radius (3.5 inch diameter); 17.5 divided by 1.75 is 10:1 ratio. That means, if you start at 100 inch pounds of torque at the beginning of the unwind roll for proper tension, the torque must be linearly decreased to 10 inch pounds of torque at the core to maintain constant tension.

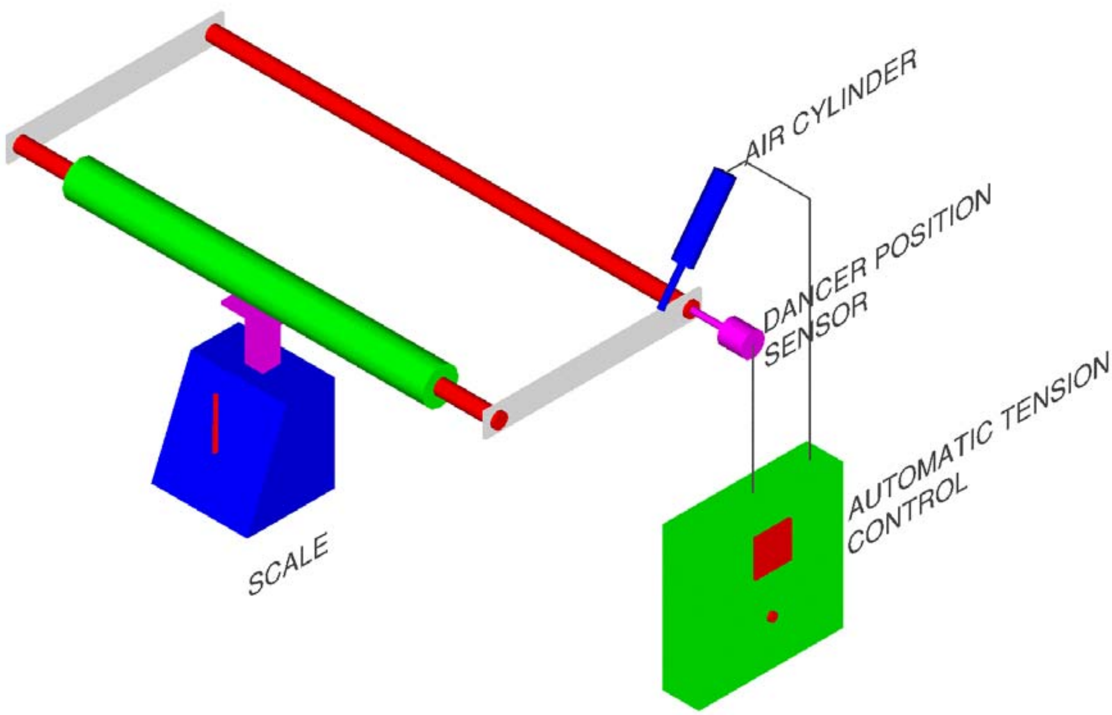
The machine designer must determine required tension levels for each zone. Often times required tension levels can only be determined after actually running the web through the machine, since all webs and all processes are somewhat unique. TAPPI (Technical association of the Pulp and Paper Industry), as well as many other industry organizations, publish *estimated* proper tension levels for several different types of webs and laminations. However, keep in mind these values are only guidelines and "best estimates" based on many years of combined industry experience. The actual best tension to run your specific web and process will, most likely, vary from the guideline. Another very general rule of thumb is proper web tension is usually between 10-25% of the tensile strength of your web.

You can measure the tension at which you currently run your process. There are several methods for doing this.

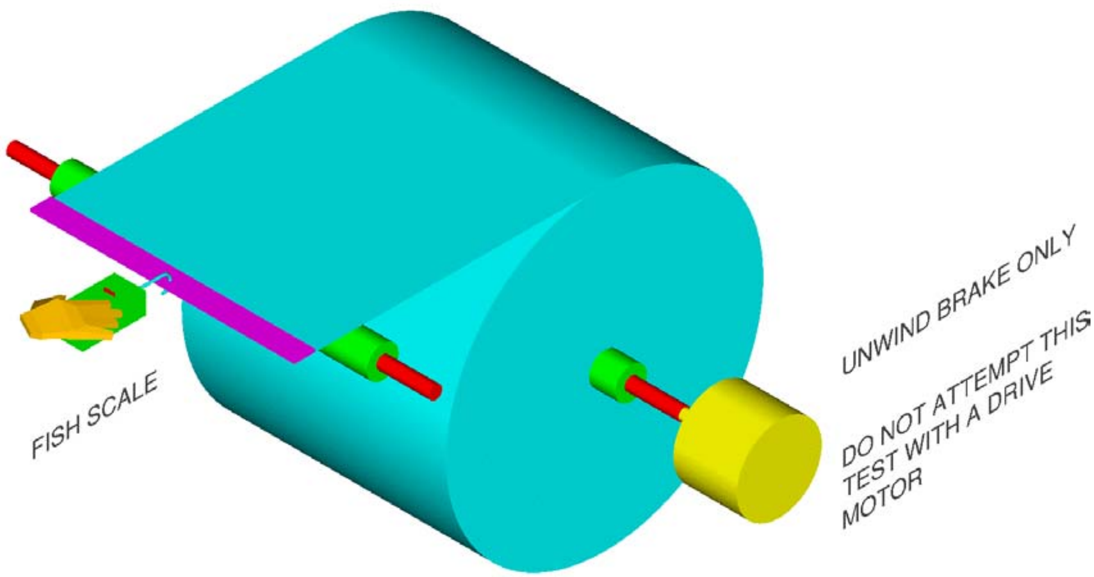
- If you already have a load cell tension control, it normally has the ability to display actual tension in total pounds across the web. You can also purchase load cells with only a display (no control) if you would like to measure tension within any zone in your machine.



- If your machine has dancers, you can calculate the loading of the dancer on the web if you know the web geometry and the loading force on the dancer. To do this, you will need a drawing of the dancer and web path through the dancer. You also need to know the type of loading and the force applied. Another simpler method would be to place a scale of some sort to measure the force the dancer is loading on the web. Do this without web threaded through the dancer. Remember, as long as the dancer remains somewhere within its travel (between its physical limits of completely full or completely empty) the tension on the web is equal to the loading in the dancer.



- Another crude but very effective way to measure tension in the unwind zone is the "fish scale method". This method works for the unwind zone only. It can only be utilized if there is a brake on the unwind station. Unwrap a small amount of material off the unwind roll. Set the unwind brake to the torque output normally set for a machine run. Wrap the leading edge of the web around a bar and hook the "fish scale" through the bar. Pull on the fish scale until the unwind starts to turn. Record the weight reading on the fish scale. This is the actual tension on the web, at this point. Divide the total weight by web width in inches to get PLI (Pounds Per Linear Inch). Do not attempt this method of measuring tension if there is a drive motor on the unwind or for a rewind with a drive motor. Serious injury could result if this method of measuring tension is attempted when there is a drive motor at the unwind or rewind zone.



- Tension can also be calculated if you know the model of a brake or clutch, the output level to that brake or clutch at a given roll diameter. By knowing the torque output of the brake or clutch we can plug the values into torque = roll radius x tension and extrapolate the actual tension the brake or clutch is delivering to the web.

There are many considerations when designing or specifying desired control for each zone. We will discuss both diameter measurement (open loop) controls and tension measurement (closed loop) controls and how each type of control fits in to each type of tension zone.

Taper tension

Everything we have discussed so far is based on constant tension applications. Do not confuse constant tension by varying (or tapering) torque to achieve constant tension as taper tension. Taper tension is NEVER desired for the unwind or internal zones. As a web is unwound and is processed, constant web tension is ALWAYS desired. Taper tension is normally desired in the rewind zone.

As a roll is rewound each layer builds up compressive forces which can cause inner layers, toward the core, to buckle. Wrinkling, starring and crushed cores will occur if these compressive forces become to great. Taper tension relieves these compressive forces by actually decreasing web tension as the roll builds. The amount of taper tension is normally measured in percentage of set tension. For example, using the same 3.5 inch core diameter and 35 inch outside roll diameter, if taper tension was set to 50%, the tension will be linearly decreased from 3.5 inch core to 35 inch roll diameter so the tension will be half at the outside of the roll compared to the core.

How do tension controls work?

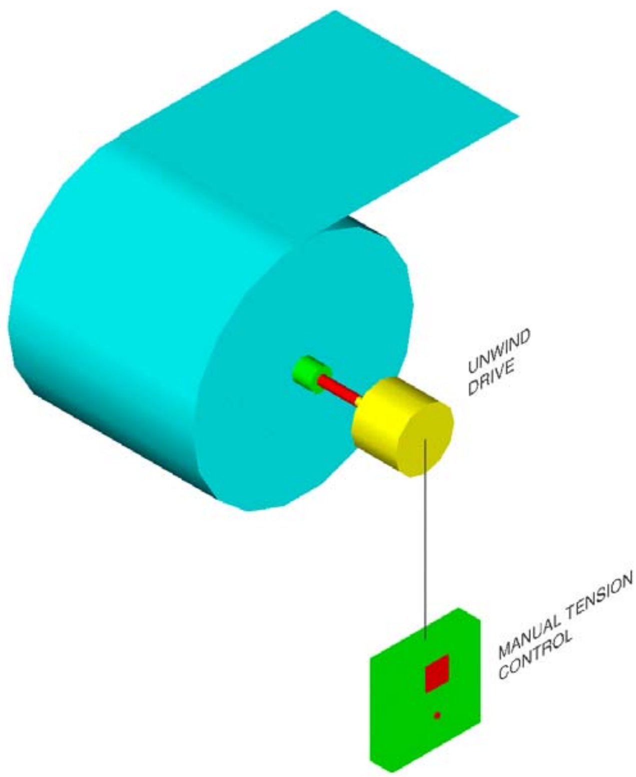
A word about the term drive

In many of the descriptions throughout this presentation I refer to the term "drive". I am using this term as a purely generic term to describe a mechanical device that delivers torque to a roll of material or driven roll(s) in a converting machine. This device could be a motor, brake or clutch. This presentation is not meant to detail drive mechanisms; instead its intent is to describe the fundamental mechanics of tension control systems.

Manual tension control

The simplest and least expensive method of tension control is manual. They can be as simple as a potentiometer adjusting the torque output of a drive or magnetic particle brake or clutch or an air regulator adjusting the air pressure and therefore torque output of an air brake or clutch. This control method can be used in all three tension zones. Obviously, it is the least accurate of all types of tension controls because it relies completely on operator "feel" to set the proper tension. There is no feedback from the machine to verify any actual process tension levels. Often times they will have some sort of "meter" on the front of the control to display output as a reference point.

Unwind and rewind tension zones are the most difficult to control manually because of constantly changing diameters and therefore need to be constantly adjusted.



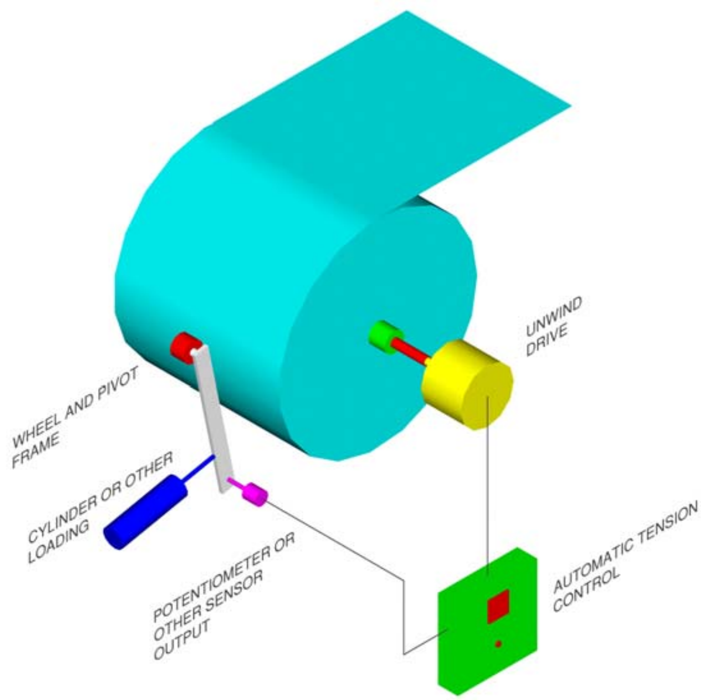
EXAMPLE OF A MANUAL TENSION CONTROL

Diameter measurement control

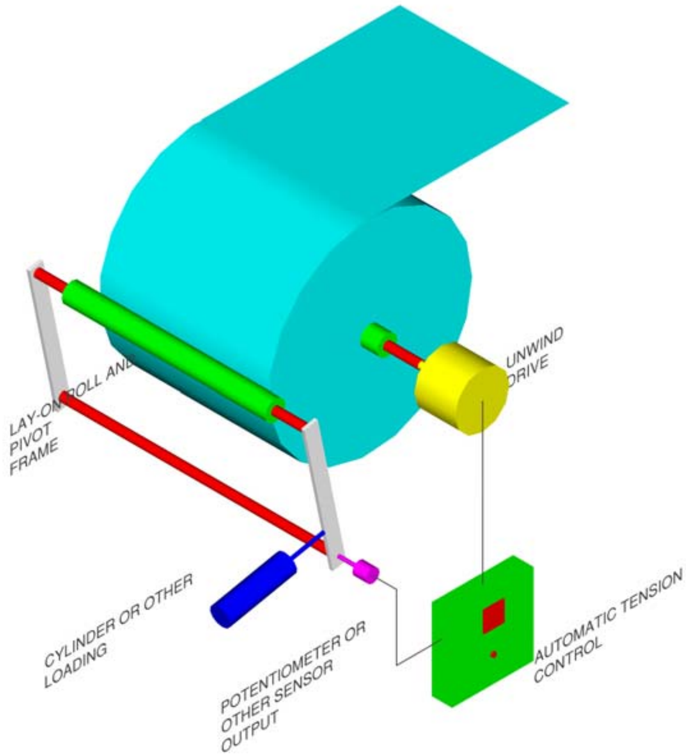
There are several types of diameter measurement controls. Each type has its own method of sensing the unwind and rewind roll diameter. These controls are extremely useful for controlling the tension off an unwind and onto a rewind. However, because they control tension by proportionally decreasing (unwind) or increasing (rewind) torque relative to roll diameter change, they do not work for internal tension zones. These types of tension controls are used strictly at the unwind and rewind tension zones. These controls can be supplied with taper tension for rewind zone applications

Diameter measurement control – follower arm

Follower arm or lay-on roll type control is the oldest technology for diameter measurement. This type of control has a wheel or roll, which lays on the unwind or rewind roll outer diameter. The wheel or roll is mounted to a pivoting arm. The pivoting arm is spring or air loaded with a sensing device mounted to the pivot point. The sensing device is usually a potentiometer, but proximity sensors and hall-effect sensors are also common. This sensing device feeds back to the tension control and an output is generated to the drive to control torque proportional to roll build.



EXAMPLE OF A FOLLOWER ARM TYPE OPEN LOOP AUTOMATIC TENSION CONTROL WITH A WHEEL ON OUTSIDE OF ROLL.



EXAMPLE OF A FOLLWER ARM TYPE OPEN LOOP AUTOMATIC TENSION CONTROL WITH A LAY-ON ROLL ON OUTSIDE OF UNWIND ROLL.

<u>Follower arm tension control advantages:</u>

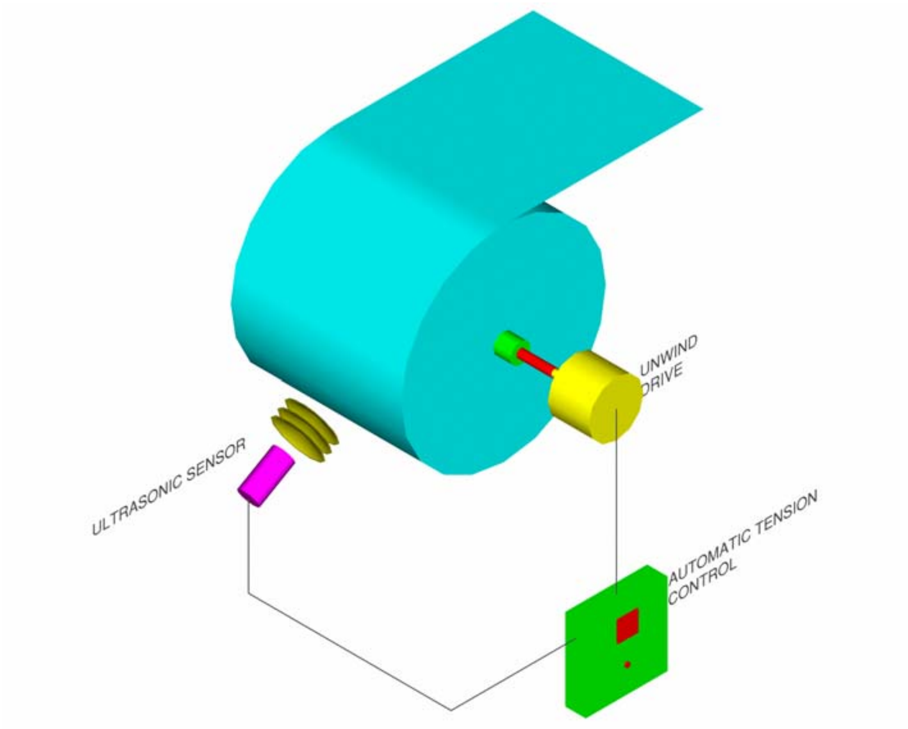
- ✓ This type of tension control is very simple.
- ✓ Good replacement for operator controlled manual control.
- ✓ Inexpensive.
- ✓ Easy to install.

<u>Follower arm tension control disadvantages:</u>

- ✓ Normally, this control does not have compensation for out of round rolls. Out of round rolls could cause this control to oscillate.
- ✓ The lay-on roll or wheel gets in the way of changing rolls.
- ✓ Major mechanical modifications are necessary to increase unwind or rewind roll capacity.
- ✓ There are a lot of mechanical parts, which will require maintenance.
- ✓ This is an open loop tension control. It does not control tension by measuring tension in the web. It controls tension by measuring roll diameter. It assumes all of the conditions effecting web tension are correct.
- ✓ This type of tension control can only control unwind and rewind zones. It cannot control internal zones.
- ✓ Material must be contacted, which could harm some sensitive materials.

Diameter measurement control – ultrasound:

Many advantages over the follower arm type tension control make the ultrasound tension control a more popular choice today. The ultrasonic sensor emits a signal that travels to the rolls surface, bounces off and returns to the sensor. The control logic measures the time it takes for the signal to return to the sensor and in that way measures distance. Since the control measures distance, it will give a linear output relative to the radius of the roll to a drive device. As we discussed earlier, the equation torque = tension x radius is linear, so if the ultrasound tension control gives a linear output relative to radius it will control drive torque through an unwind or rewind roll built to supply constant tension.



Ultrasound tension control advantages:

- ✓ This type of tension control is very simple.
- ✓ Excellent replacement for operator controlled manual control.
- ✓ Relatively inexpensive.
- ✓ Extremely easy to install.
- ✓ Gives a true linear output relative to roll diameter.
- ✓ Models of this control are available with compensation for out of round rolls to eliminate control oscilation.
- ✓ Ultrasonic sensor can be "tucked" away, out of machine operators way. It can be mounted anywhere around the roll circumference, as long as it get a clear view of roll radius.
- ✓ Modifications to increase unwind or rewind roll capacity is easy. All that is needed is to move the transducer and recalibration.
- ✓ No mechanical parts to wear out.

- ✓ Models are available with limit alarms. Such as low or empty roll.
- ✓ No material contact for sensitive materials.

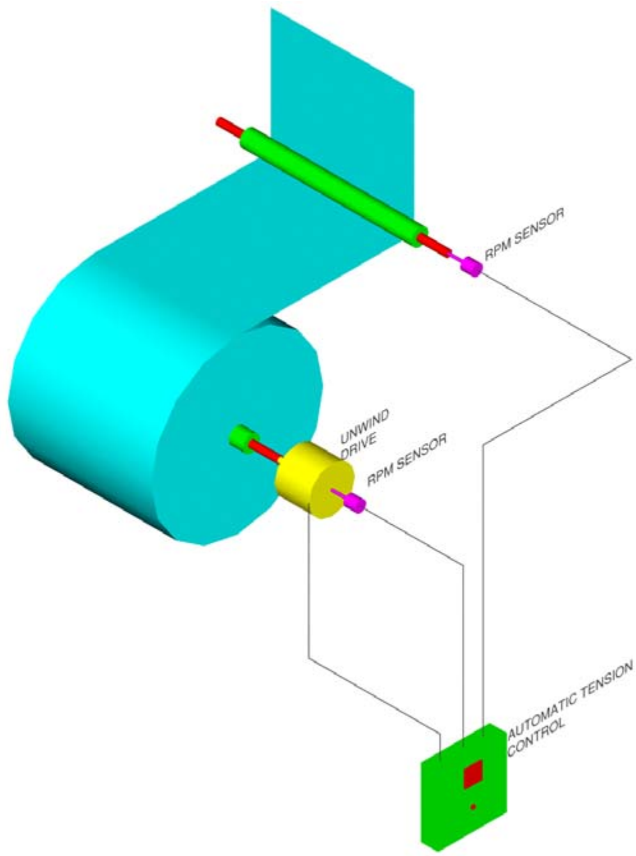
Ultrasound tension control disadvantages:

- ✓ This is an open loop tension control. It does not control tension by measuring tension in the web. It controls tension by measuring roll diameter. It assumes all of the conditions effecting web tension are correct.
- ✓ This type of tension control can only control unwind and rewind zones. It cannot control internal zones.
- ✓ Any object put between the roll outer diameter and the transducer affects it.
- ✓ Electronic calibration is necessary with initial set up.
- ✓ Some types of material, such as nonwovens, may absorb the ultrasonic signal. If the signal does not return to the sensor, it will not operate.
- ✓ The perpendicular positioning of the sensor relative to rolls centerline is somewhat critical. If the sensor is "knocked" out of position, it may not operate properly.

Diameter measurement control – diameter calculator

The last type of diameter measurement control we will discuss is the diameter calculator. This type of control uses sensors at the unwind or rewind shaft and an idler or driven roll. Both sensors detect RPM. They can be encoders or tachometer generators.

Machine speed is constant and known. Unwind and rewind roll speeds both vary relative to roll diameter. By comparing the constant known speed to the varying unwind or rewind roll speed, diameter can be calculated.



Diameter calculator tension control advantages:

- ✓ Excellent replacement for operator controlled manual control.
- ✓ Relatively inexpensive.
- ✓ Relatively easy to install.
- ✓ Gives a true linear output relative to roll diameter.
- ✓ Nothing in the way of roll loading or unloading
- ✓ Modifications to increase unwind or rewind roll capacity is easy. All that is needed is recalibration.
- ✓ No mechanical parts to wear out.
- ✓ Models are available with limit alarms. Such as low or empty roll.
- ✓ No material contact for sensitive materials.

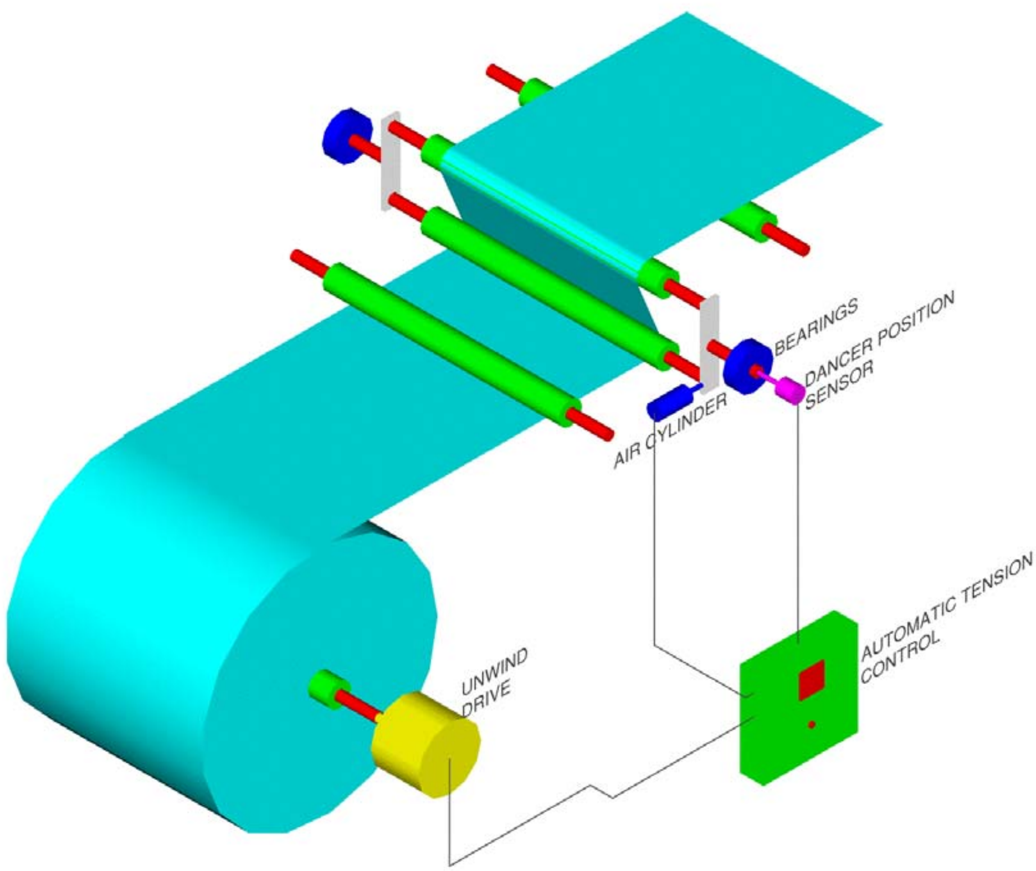
Diameter calculator tension control disadvantages:

- ✓ This is an open loop tension control. It does not control tension by measuring tension in the web. It controls tension by measuring roll diameter. It assumes all of the conditions effecting web tension are correct.
- ✓ This type of tension control can only control unwind and rewind zones. It cannot control internal zones.
- ✓ Control logic is somewhat complex (compared to ultrasonic or follower arm type).
- ✓ Electronic calibration is necessary with initial set up.

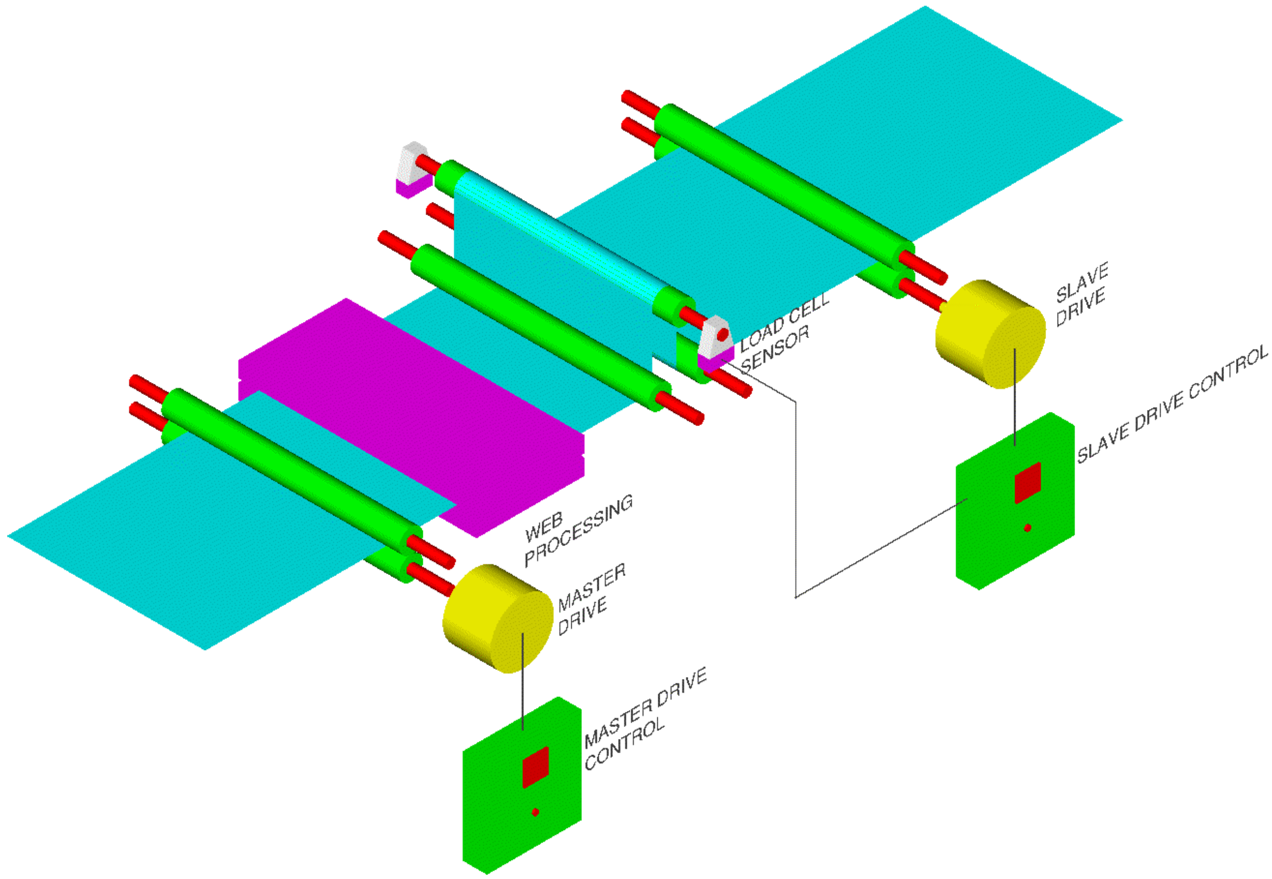
<u>Tension measurement control</u>

There are two types of tension measurement tension controls – dancer roll and load cell types. These controls are "closed loop". They control tension based on tension in the web. They will compensate for tension changes due to roll diameter change on an unwind and rewind. They will also compensate for tension changes due to splices, bearings, mechanical losses and any of forces acting on the web in the machine direction.

Because these tension controls are "closed loop" and control drives based on actual web tension, they can be used to control the unwind, internal and rewind tension zones. Unfortunately, these controls can not sense roll diameter without external inputs, so by themselves they can not supply taper tension to rewind zone applications.



EXAMPLE OF DANCER ROLL TENSION CONTROL USED TO CONTROL AN UNWIND TENSION ZONE

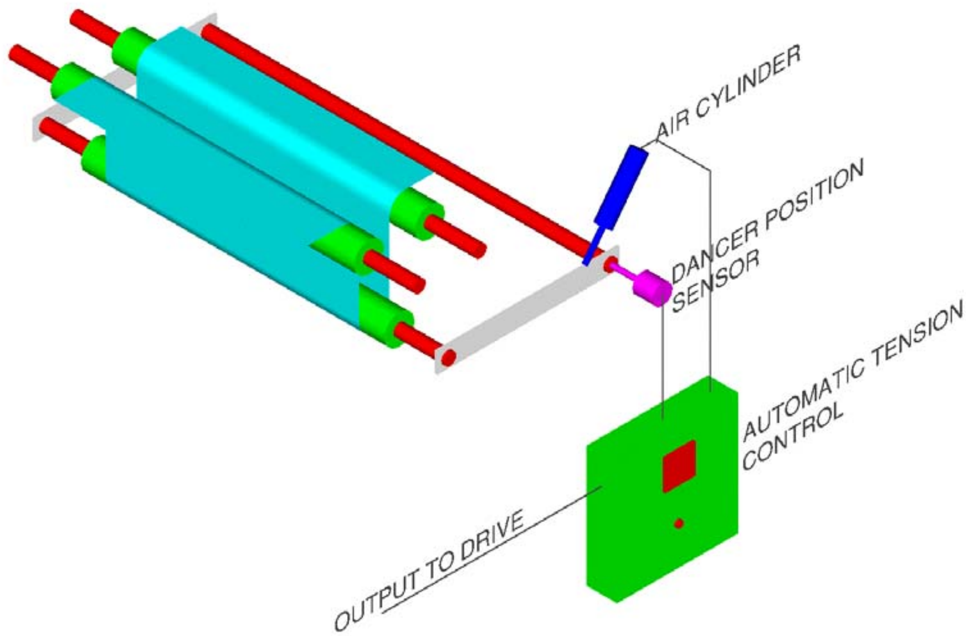


EXAMPLE OF A LOAD CELL TYPE TENSION CONTROL USED IN AN INTERNAL TENSION ZONE

Tension measurement control - dancer

There are many different designs of dancer roll tension controls. However, all dancers operate with a common principal. They all incorporate idler rolls that are “loaded” in one direction, while the web tends to move them in the opposite direction. A sensor detects the position of the dancer and tells the drive to increase or decrease in speed or torque to add or remove material from the dancer. As long as the dancer roll remains between its physical limits (completely empty or completely full) tension is constant on the web.

Some of the most common types of dancer roll designs are pivot arm, linear and rotational. One advantage to using dancer roll tension controls that is consistent among all designs is they all have some amount (some designs more than others) of web storage. In other words, dancers actually accumulate a certain length of web in the machine direction. That means they can be designed to be mechanically stable through large roll build ratios (at the unwind and rewind) and will absorb tension fluctuations due to splices, defective bearings or other factors. Dancers not only control torque and/or speed to keep tension constant, they also absorb tension fluctuations, so web tension down stream of the dancer is kept smooth.



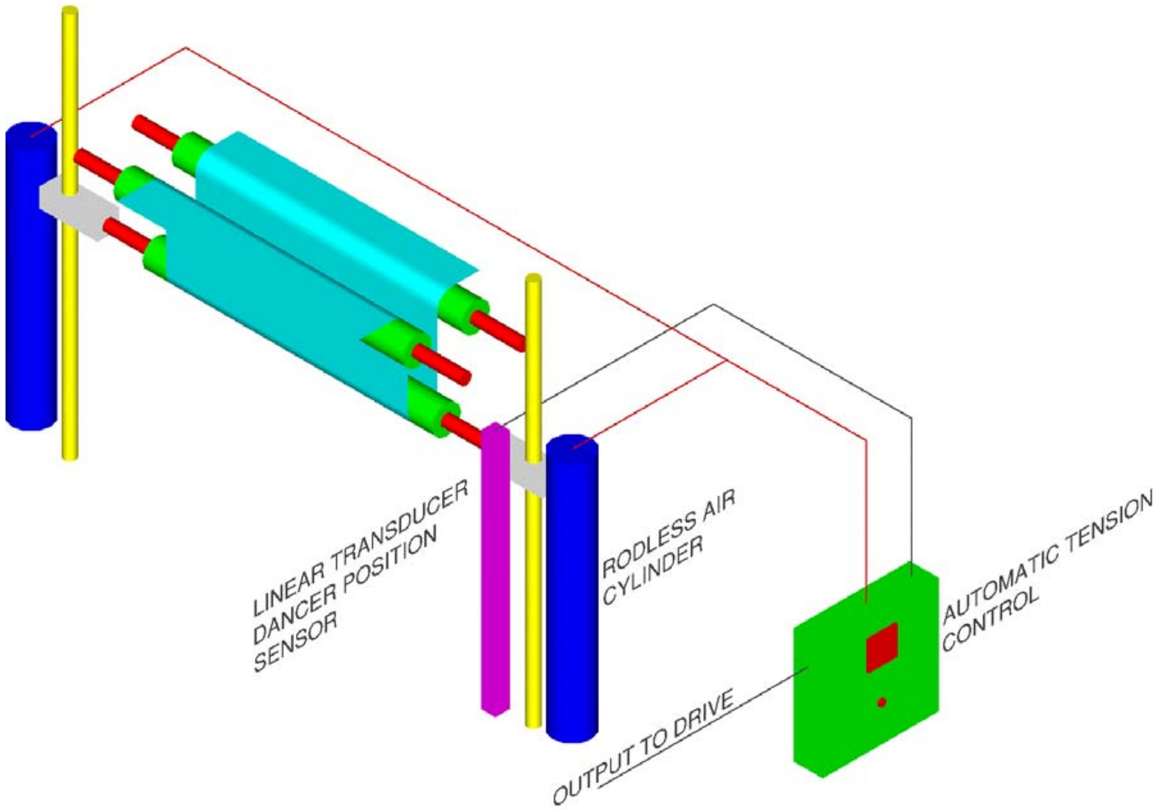
EXAMPLE OF PIVOT ARM TYPE DANCER ROLL TENSION CONTROL

<u>Pivot arm type dancer roll tension controls advantages:</u>

- ✓ This design of dancer is one of the simplest.
- ✓ Most common design of dancer roll tension control.
- ✓ Least expensive dancer design.
- ✓ Can be designed with a large or small amount of web storage, but takes up a lot of space.

<u>Pivot arm type dancer roll tension control disadvantages:</u>

- ✓ Gravity must be taken into account during design.
- ✓ Unit can be bulky and difficult to fit into an existing process.
- ✓ Momentum and inertia is a concern.



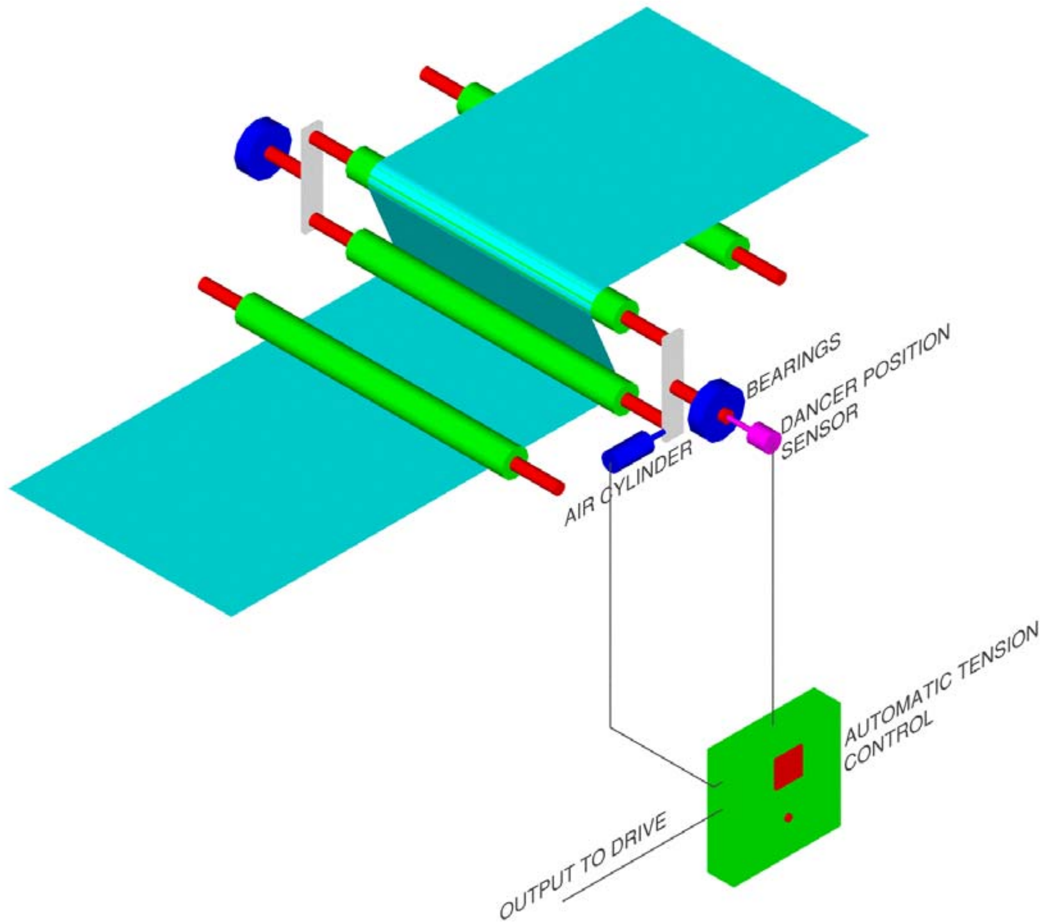
EXAMPLE OF LINEAR DANCER ROLL TENSION CONTROL

<u>Linear type dancer roll tension controls advantages:</u>

- ✓ This design is compact.
- ✓ Large amounts of web storage are available. Especially with multiple web passes. Excellent design for accumulation needs, to allow splices on the fly.
- ✓ Small package can be easy to install in existing equipment.

<u>Linear type dancer roll tension control disadvantages:</u>

- ✓ Gravity must be taken into account during design.
- ✓ Can be a very complex design.
- ✓ One of the most expensive designs. Rodless cylinders and linear transducers are very expensive.
- ✓ Momentum and inertia is a concern.
- ✓ Rodless cylinders are not available in a low friction model.



EXAMPLE OF A ROTATIONAL TYPE DANCER ROLL TENSION CONTROL

<u>Rotational type dancer roll tension controls advantages:</u>

- ✓ This type of dancer roll design is not effected by gravity. It's dancer rollers are counterbalanced with each other.
- ✓ Momentum and inertia is greatly decreased with the "push/pull" motion.
- ✓ Generous web storage in a small package.

<u>Rotational type dancer roll tension control disadvantages:</u>

- ✓ This design can be expensive.
- ✓ This dancer roll design is somewhat complex.
- ✓ Web storage amount is fixed and determined by design. Increasing web storage is a new design.

Friction, gravity, momentum and inertia are all “enemies” of dancer rolls. These factors must be accounted for when designing dancer roll tension controls.

- Frictional losses greatly affect the accuracy of dancer roll tension controls. Low friction cylinders, such as glass lined or rolling diaphragm cylinders, should be used. Stay away from standard o-ring type cylinders or any type of cylinder with a high breakaway force.
- Momentum and inertia affect stability and accuracy of dancers. Remember a body in motion wants to stay in motion, so dancers will want to keep moving in the direction they are headed. This could cause the dancer to be unstable and tension spikes. Design dancers as lightweight as possible and avoid weight loading of dancers this will greatly reduce momentum and inertia problems.
- Gravity affects dancer accuracy. The weight of the dancer must be overcome by the web tension order for the dancer to operate. This weight of the dancer is in addition to the loading on the dancer when considering total web tension delivered to the web. Design dancers so gravity least affects them. Rotational type dancers are not prone to gravity problems because the dancer rollers counterbalance each other. Instead of designing a pivoting or linear dancer to move perpendicular to the floor, design it to move parallel to the floor. This will greatly reduce gravity problems.

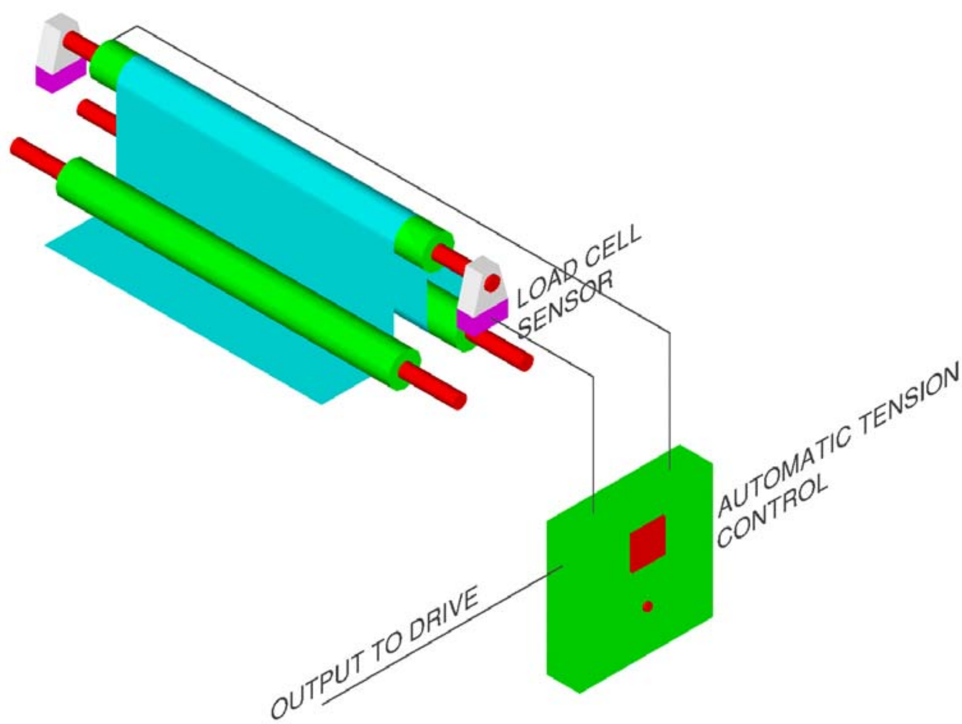
There are many methods of loading dancer roll tension controls. Older units may be loaded with weights. If you need more or less tension you add or subtract weight. Newer dancer roll tension controls may use air cylinders for loading with pressure regulator valves. If you want more or less tension your turn the valve to allow more or less air pressure into an air cylinder. Today dancers are manufactured with electric to pneumatic converters loading low friction cylinders, such as glass lined or rolling diaphragm types. Electric to pneumatic converters are electronic circuits, which receive a signal voltage and output a proportional air pressure. The actual air pressure output is sensed with a pressure transducer and controlled with an electronic pressure regulator. This closed loop sensing circuit allows for very accurate dancer roll loading.

Older dancer position sensors are normally potentiometers. The problem associated with using a potentiometer to sense dancer position is that you have mechanical parts within the potentiometer (wiper against a resistance coil) that constantly wear against each other. This type of sensor may loose accuracy over time and may need periodic replacement. Newer dancer position sensors can be digital potentiometers, encoders or proximity sensors with analog output. These types of sensors do not have mechanically wearing parts, so their accuracy is not affected over time and the need for replacement is rare.

Tension measurement control – load cell

Load cell tension controls utilize strain gauges and other weight measuring devices to measure the "weight" applied to an idler roll due to tension. The force exerted to the idler roll due to tension in the material is proportional to wrap angle around the roll. The example below shows 180° wrap. However, load cell tension controls work with any amount of wrap angle up to 180°. Wrap angles around the idler rolls utilizing load cells must not vary through roll diameter, that is why these controls use lead-in and lead-out idler rolls.

The machine operator sets the desired tension. Normally measurement signals are generated on both sides of the idler roll and fed into the control unit. The control accepts both signals and processes them together. Process values and set values are compared and an output is generated and sent to the drive to keep tension constant.



EXAMPLE OF LOAD CELL CONTROL

Load cell tension controls advantages:

- ✓ Excellent, accurate tension control at the unwind, rewind and internal zones.
- ✓ Many makes and models to choose from.
- ✓ Very accepted though out the industry for tension control.

- ✓ “High tech” controls are available with IO for PLC interface and data acquisition.
- ✓ Auto-tune units are available to eliminate manual calibration.
- ✓ Inexpensive, simple units are available.
- ✓ Very easy to install at any idler roll location.
- ✓ Minimal machine modifications are necessary to utilize this control.

<u>Load cell tension control disadvantages:</u>

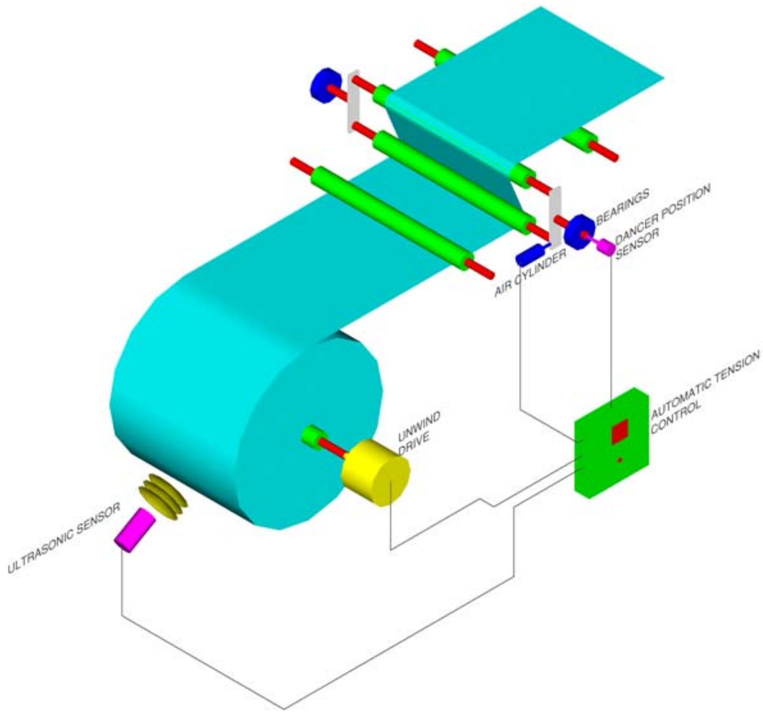
- ✓ No mechanical web storage for web tension fluctuations.
- ✓ Web tension can be unstable. Especially in unwind and rewind zone control with large roll build ratios.

It can be difficult to properly design both dancer roll and load cell tension controls to have 100% “authority” over an unwind or rewind drive. Large roll build ratios, very high and low speeds and elastic webs can make both types of closed loop controls very unstable. Combination open loop / closed loop controls are available to help with this problem.

Open loop controls are very stable because they are designed to measure distance (roll build). Unfortunately, open loop controls lack accuracy because they do not know what the tension actually is in the web.

Closed loop controls are very accurate because they actually measure tension in the web and control a drive to keep tension constant relative to a set point. Unfortunately, closed loop control can lack stability when controlling unwind and rewind tension zones because they do not know distance (roll build) and have to control large ratios in a relative small span.

Combination controls utilize both open loop and closed loop technology for unwind and rewind zones. The open loop control in the system normally controls 90% of the output to the drive and the closed loop control “trims” that output 10%. This makes unwind and rewind zone control very stable and very accurate. Theses controls utilize roll diameter information, so taper tension for rewind applications is available.



EXAMPLE OF A COMBINATION ULTRASOUND / DANCER TENSION CONTROL

Combination closed loop / open loop tension control advantages:

- ✓ Very accurate, very stable tension control for very demanding applications.
- ✓ "High-tech" controls are available with IO and PLC interface.

Combination closed loop / open loop tension control disadvantages:

- ✓ High cost of two tension controls.
- ✓ Mechanically and electronically complex.

When tension controls are applied properly, they will decrease waste due to web defects. They will allow operators to concentrate their efforts in other critical areas of your process. Tension controls can allow you to run your process faster. They can even allow you to run different webs and processes through your machine. Tension controls are essential to increasing your profits.