GOLDENROD CORPORATION

DIFFERENTIAL WINDING SHAFTS

When is it necessary to use a DIFFERENTIAL SHAFT?

Differential Winding is used when winding multiple cores on one air shaft (SIMPLEX) or two shafts (DUPLEX) and can be used in various machine designs. These designs can be “Center Winding” with or without a single or multiple lay-on rollers or “Center Surface” winding or “Minimum Gap” winding. Each machine design has advantages and disadvantages and the design that is best for you is usually dictated by the material you process.

If you’re trying to overcome the following manufacturing defects in your slit/rewind operation, there is a need for differential shafts:

- Film caliper variation
- Coated products w/ inconsistent thickness
- Laminates with variation in substrate thickness
- Other situations where thickness varies across the web

What are symptoms of these operating defects?

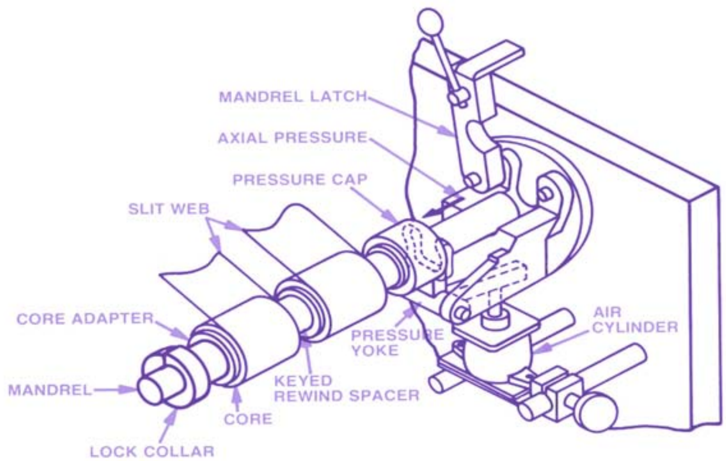
- Wound roll tightness variation between rolls wound on the same shaft
- Wound roll tightness variation between rolls would on a duplex machine
- Individual core crush or locking
- Individual slit web breaks
- Dished rolls
- Coated products with adhesive squeezed out from between layers

What is true differential winding?

Clutching adjustment that allows tension to equalize from one slit roll to the next on the same shaft or rewind operation. Each individual rewind roll is completely isolated from all others.

Differential "Slip" Shaft Options:

OPTION 1. Side Loaded Cores & Spacers on a Keyed Mandrel (Yoke System) –



This older technology works by loading a stack of cores and spacers laterally against a fixed collar. Cores are allowed to rotate, but spacers are keyed and rotate with the shaft at a set over speed. A yoke controlled by air or a mechanical lock nut and spring applies pressure on the spacer & cores. Friction is applied on the sides of each core by the spacers. The cores are allowed to rotate at their own rate. As roll diameter increases, so does the air pressure in the yoke. The mechanical lock nut & spring design is very limited and pressure cannot be changed as roll diameter builds.

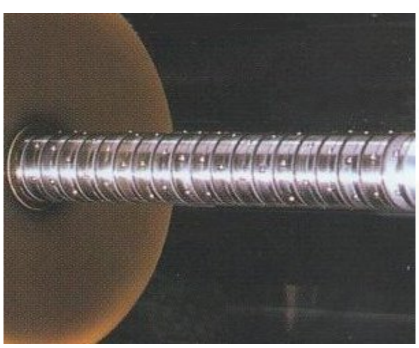
<u>Advantages</u>: Low Cost (found on older machines); good for winding roll widths under 7/8" because the spacer help eliminate roll wobble on narrow cores.
<u>Disadvantages</u>: Low roll weight capacity; <u>set-up time is very long;</u> user must inventory a wide variety of core spacers; heat generated by the friction of the spacers against the core can be extreme; inconsistent tension across the web; excessive dust.

Option 2. Core Clutch Design –

Core clutch shafts (Goldenrod Models 1250 DFX & DFB) create torque proportional to core width. Friction ledges are controlled pneumatically and contact the cores inner diameter. Wider cores
engage more frictional elements and receive more torque than narrow cores. Heat, dust and torque variations are much improved over the older "Yoke" system.

<u>Advantages</u>: Greater roll weight capacities, widest tension range; most widely accepted design and easy to maintain; repeatable results with good quality cores; acceptable for variable slit widths of 1" and greater; set-up time is fast.
<u>Disadvantages</u>: Dependent somewhat on core quality; core rotates on shaft body.

Option 3. Locked Core Internal Clutch Design –



(Goldenrod Model 1250 CL) A cam lock ring grips and locks the inside diameter of the core. The inside diameter of the cam lock ring then becomes the point of friction on the internal pneumatic shaft. The cam lock rings rotate on the internal pneumatic shaft which utilizes engineered materials (high temperature plastic or felt over a bladder system) to expand and control the amount of slip.

Advantages: Locks lateral movement without core stops; not dependent on quality of cores, lower tension sensitivity; set-up time is fast; less dusting.
Disadvantages: lower roll weight capacities meaning excessive deflection will restrict clutch collar functioning properly; limited over speed capability; inconsistent core positioning.

NOTE: All of the above options are available from Goldenrod. Options 2 & 3 significantly reduce set-up time between changeovers. Contact your Goldenrod Representative to learn which of the 3 options is best for you.

Is it time for you to upgrade your machine? - 4 Scenarios

The first question a Goldenrod Representative will ask you is "Are you differentially winding now?"

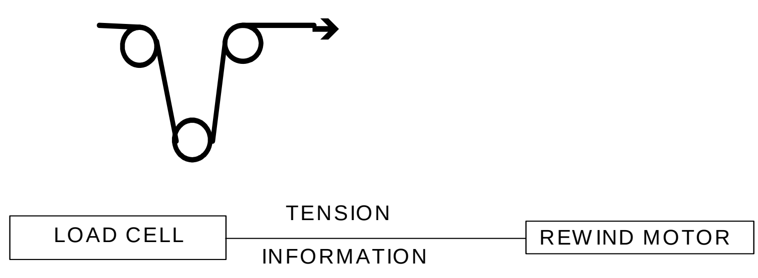
If you answer "**NO**" – please review Scenario 1 below.

If you answer "**YES**", please review Scenarios 2, 3 & 4.

If you are differentially winding, other questions that need to be addressed are:
"How are you controlling your over-speed on your rewind shafts?"
"Does your current differential system measure roll diameter?"
"Does your current differential system measure web tension?"

Scenario 1 – If you're NOT currently differentially winding, or in other words…..you are "Locked Core Winding", using a conventional lug, button or leaf shaft and would like to rewind your material on differential shafts – you're machine may need to be upgraded. This upgrade may involve upgrading your motor/drive system prior to installing differential shafts. Contact your Goldenrod Representative for more information and upgrade assistance.

Most "Standard" Systems with Locked Core Air Shafts



*No Rewind Shaft Over-speed Provision- Locked Core (No slippage of the cores)
*Tension information (if measured) usually controls the rewind motor speed

Scenario 2 – Improving your current YOKE System. On older machines, the Yoke system may be tied to a single motor/drive system that controls all driven rollers and over-speed for the differential shafts is managed by belt/pulley and/or clutch system. If in fact you do have a single drive system, your machine may need to be upgraded prior to retrofitting new differential shafts. This upgrade may involve upgrading your motor/drive system. Contact your Goldenrod Representative for more information and upgrade assistance. Once we assess your individual machine, we will be in a better position to offer you a compete solution.

For successful differential winding, we need to control **<u>tension and over-speed</u>** of the differential shaft. We would like to have both web tension and roll diameter information to do so.

Tension

In general, as the roll diameter increases, the air pressure in the shaft must be increased to maintain the same tension. This is due to the change in moment arm. Roll weight increases as diameter builds and taper tension will reduce the amount of air pressure change required.

Taper tension is a method of decreasing web tension as roll diameter increases. Taper tension helps prevent telescoping, crushed cores, and overly tight or loose rolls. Any roll build in excess of about 18" will require taper tension.

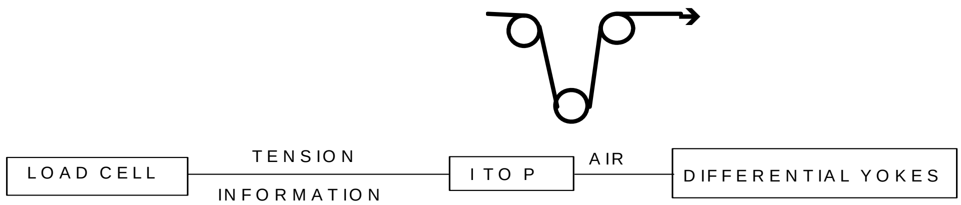
Actual tension information is fed to the differential shaft by means of an I to P (current to pressure transducer). The I to P converts the electrical signal from the load cell to a given air pressure supplying the shaft. The signal from a load cell is ideal because it measures actual tension. Often times however, there is not room for installing new load cells when retrofitting older machines.

Obtaining diameter information through an ultrasonic sensor and using that to control the air in the differential shaft will work. This is not as accurate as a load cell but it is much more accurate than the alternative of having an operator manually adjusting the air as he notices changes in the rewind roll diameter. If we assume that we know the required air pressure for a given material at core, then we can trim that pressure as the diameter increases. The operator programs a starting air pressure and as the diameter increases the system automatically changes the air pressure. This system can also account for increases in roll weight and taper tension.

Overspeed

If we know the line speed (usually a rotary encoder on an idler of known diameter) and the rewind roll diameter we can calculate the required rewind motor speed. The roll diameter information can again be an ultrasonic sensor, a lay-on type position sensor, shaft position sensor (center surface Cameron type), or calculated from material thickness and footage. Most machines have a speed sensor of some type. This tension and over-speed information need to be fed to a simple controller to maintain over-speed and ultimately create a successful differential rewind upgrade.

Many “Standard” Differential Systems- Differential Yoke Systems



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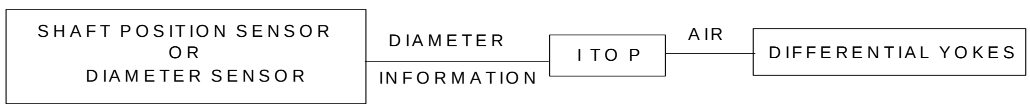


*All Systems Have Over-speed, Many Are Adjustable
* Some Systems Have Diameter Controlled Over-speed

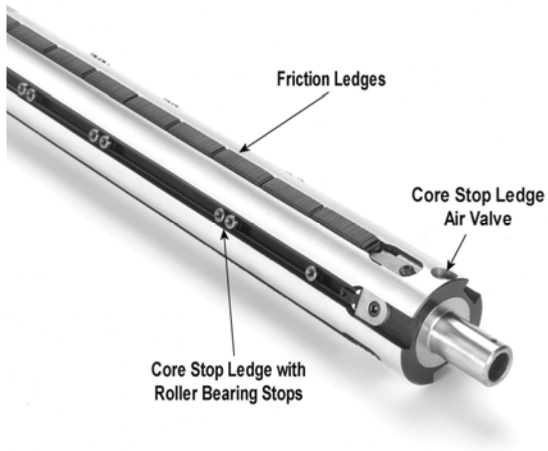
Scenario 3 – Upgrading from a YOKE system that does have a separate rewind motor/drive system to a Core Clutch Differential Shaft Design (Goldenrod Model DFX or DFB) will eliminate production bottlenecks.

A constant air source is required to control air pressure to the differential ledges for the 1250 DFX/DFB. This air supply should be controlled by a load cell or roll diameter sensor. A load cell is preferred because it gives an actual tension value, not calculated tension based on roll diameter. The tension information/signal needs to be converted through an “I to P” (current to pressure transducer). This changes the electronic tension signal to an air pressure value. I to P converters may need to have fine incremental adjustments for some very low tension applications.

Core stop ledges are designed to help locate the core along the length of the shaft. They are actuated with a separate air supply. This may be an air valve on the face of the shaft, filled with a separate air gun supplied by Goldenrod or a rotary union.

The core stops are positioned on each side of the core along the length of the ledge using set screws and a hex wrench. The core stops are mounted in an easy to change cassette. By loosening one screw, the operator can remove the complete core stop cassette allowing for even faster changeovers and little machine down time.

Goldenrod Model 1250 DFX



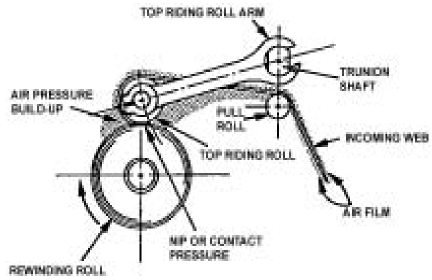
When you're winding narrow slits, use cores with tight inside diameter tolerances to enhance the quality of the finished roll. The air pressure in this shaft provides force to cause tension, and it is not intended to center the core. Six inch and three inch ID cores are readily available with tolerances +/-.007". A good quality core with a high psi crush rating is important. Clean cut edges that are parallel help eliminate the possibility of dust forming.

The differential shaft must be driven at a 3 – 10% over speed at all times. All the cores need to slip continuously. Some cores simply slip more than others in order to maintain the same tension. As the roll diameters build, the differential shaft rpm must decrease to maintain the same over speed, and the air pressure usually increases to maintain the same tension. A feedback loop that compares the line speed, roll diameter, and rewind motor speed can be used to control the over speed.

System Considerations

The air shaft must control the tension. The winding system must be either center driven or center-surface driven.

A purely surface winder configuration is not an acceptable application (i.e. two drum winder). Center surface applications are acceptable but extremely low tensions may be difficult to achieve as the lay-on pressure affects minimum tension capabilities. Lay-on rolls can contribute considerable force and affect the minimum tension. Doing an "S" wrap around the lay-on helps remove the trapped air from the web while minimizing the affect of the tension caused by the lay-on. As the roll diameter builds the roll weight can also contribute to the tension.



Lay On Roller

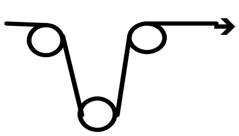
How do we get constant/adjustable air to the shaft? There are a variety of ways. Goldenrod offers an “Air-Thru” safety chuck allowing air flow through the chuck to the shaft. “Lift Out” shafts need an easily removable air inflation system. Quick disconnects can work well. Non-rotating quick disconnect connectors may be used in front of the rotary union. This ensures that the rotation happens in the union and not in the quick disconnect fitting. The Goldenrod DFX-AID Air Injection Device is a simple frame mounted mechanism designed to supply constant air to lift out shafts. Cantilevered or flange mounted shafts are ideal for supplying constant air to the shaft. Often these shafts can be supplied with dual port rotary unions that eliminate the need for manual air gun inflation of the core stop ledge. This device uses a rubber tipped nozzle which interfaces the end of the shaft and has been utilized in a number of applications.

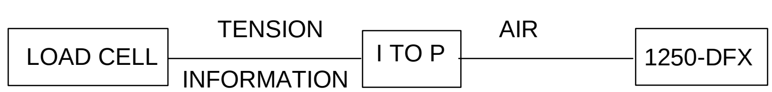
For the best method of introducing air to your differential shaft, contact Goldenrod.

GOLDENROD 1250-DFX, DFB and Cam Lock Differential Shaft Control

Goldenrod 1250 DFX & Cam Lock Style Shafts Often “Plug Into” The Systems That Utilize Over Speed Control

Goldenrod 1250 DFX & Cam Lock Differential Shafts Require:





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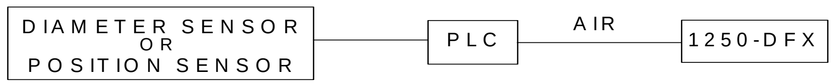
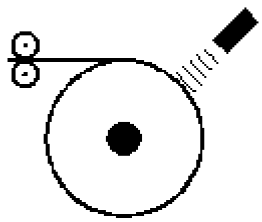




(Example of Ultrasonic Roll Diameter Sensor)

This ultrasonic sensor can provide an output proportional to the diameter of a roll of material as it winds on a machine. Diameter measurements are used for the following: Control a motor to maintain or match line speed; Inertia compensation in a tension control; or Control a clutch or brake to change material tension as the diameter of the roll changes.

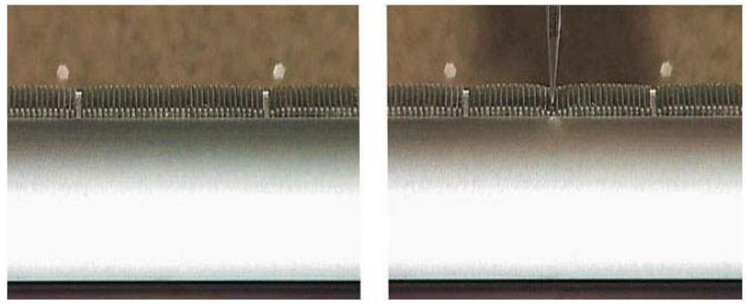
Features of the Model 1250 DFX / DFB (Available in 1" diameters up to 24" plus!!!! Ask about our Aluminum & Carbon Fiber options)

CSC - DFX Cassette Style Core Stop Ledges

DFX Rotating Bearing Core

Side-lay Adjustable Core Stop Ledges

Adjustable Crimping Lugs for Differential Ledges



- 1250-DFB <u>Surface Roller **B**earing</u> Designed to Reduce Tension due to Roll Weight on shaft diameters of 6" and up. This patented feature keeps the inside surface of the core from dragging on the shaft OD allowing the tension ledges to accurately control tension.

OPTION 4 – Upgrading from a YOKE system that does have a separate rewind drive system to a Locked Core Internal Clutch Design…..or Goldenrod Model 1250 CL Cam Lock.

The upgrade considerations for this shaft are very similar to those covered above. A constant air source is required to control air pressure to the differential ledges found on the 60 mm multiple bladder base shaft under the cam lock rings. This air supply should be controlled by a load cell or roll diameter sensor. A load cell is preferred because it gives an actual tension value, not calculated tension based on roll diameter. The tension information/signal needs to be converted through an "I to P" (current to pressure transducer). This changes the electronic tension signal to an air pressure value. I to P converters may need to have fine incremental adjustments for some very low tension applications.

Cam lock rings are situated along the length of the shaft. The width of the individual rings is determined by minimum slit width. Once the operator determines the desired position of the core on the shaft, a quick turn locks the core in place. No tools are required.

Goldenrod Series 1250 CL (Cam Lock)

The differential shaft must be driven at a 3 – 10% over speed at all times. All the cam lock rings need to slip continuously. As the roll diameters build, the differential shaft rpm must decrease to maintain the same over speed, and the air pressure usually increases to maintain the same tension. A feedback loop that compares the line speed, roll diameter, and rewind motor speed can be used to control the over speed.

System Considerations

(See System Considerations – above)

Can you retrofit differential shafts to an "IN LINE" system? YES.

1250 Differential Shaft Application Considerations for Simplex Turret Rewinds

Our Model 1250 DFX/DFB works best in this application. As in all differential shafts, we need to control the air pressure to the shaft and the over speed of the rewind motor. A load cell or a diameter sensor should control the air pressure. The rewind motor speed needs to be 3 – 12% faster than the line speed for all roll diameters. Measuring the roll diameter and the line speed usually does this. The correct rewind motor speed can then be calculated.

Considerations specific to simplex turret rewinds:

- Where to mount the diameter sensors? Turrets are not always indexed to the same location, so mounting the ultrasonic sensor to the floor may not be an option. If the sensor is mounted on the turret armature, wiring can sometime be a challenge.
- How to supply controlled air pressure to the 2 differential shafts? Air must be brought in to both differential shafts through the turret. The air should be turned off when the shaft is removed from the turret. Ideally the shafts would have separate, independently controlled air pressures.
- If the system performs an automatic splice, the differential shaft must be supplied full air pressure at the instant of the splice for consistent turn-ups.
- What is the spacing between the cores? Standard core stops on our 1250 DFX models are 0.250" in diameter. Does a core stop fit between the cores? Often customers find it easier to use PVC spacers cut to 0.125 – 0.250" in width. A fixed core stop ring can be mounted on the body of the shaft as a reference to butt core against. This facilitates the accurate loading of cores.

Question???? Call 1-800-GOLD-ROD

www.goldenrodcorp.com

Visit our Web Site to find your local Differential Expert.