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Dynamatic®

World's leading manufacturer of Eddy Current drives, brakes and controls

TENSION CONTROL AND WINDER

Dynamatic® Eddy-Current equipment, because of its simple, flexible speed adjustment and control characteristics, provides an inexpensive and accurate means of solving tension control problems. You will find tension control and winder applications in all industries.

Constant tension winders are typically divided into two main categories: centerwinds and surface winds. The determining characteristic is the point of power input. On centerwinds, the power is introduced at the core shaft or center of the roll. On surface winders, the power is applied to the surface of the winding roll.

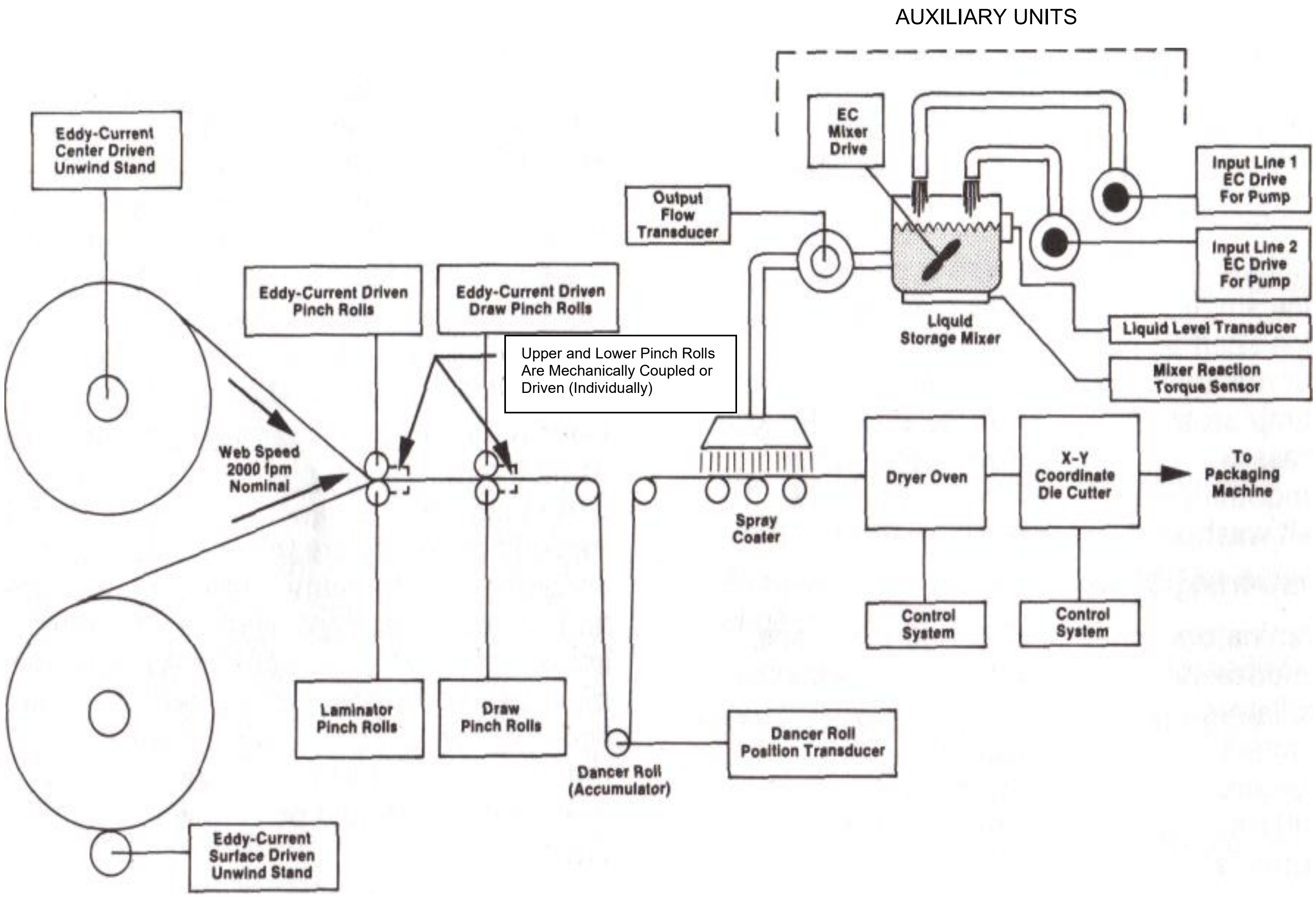
Surface winders normally make use of one or two drums against which or upon which the roll is wound. Torque applied to the drum shaft always reacts with the fixed radius of the drum to provide tension. This radius is constant regardless of wound roll diameter. Therefore, constant torque at the drum will result in constant tension on the web. Surface winders are, then, constant torque drive applications. Relatively straightforward speed controls involved.

Centerwinds are significantly more complex. As the web is wound, the diameter (or radius) increases. The circumference also increases. With a constant FPM (foot per minute), the winding roll will be forced to decrease in speed as the roll builds up. Thus, the winder drive is faced with an ever-increasing torque arm and a continually decreasing RPM requirement. To maintain constant tension on a centerwind, a drive must deliver the proper value of torque at the proper RPM at any instant in the roll buildup.

Three mechanical relationships exist on centerwinds under constant tension conditions:

1. Torque versus diameter in a linear function.
2. Torque versus RPM is a hyperbolic function.
3. Diameter versus RPM is a hyperbolic function.

AUTOMATIC LAMINATOR MODEL



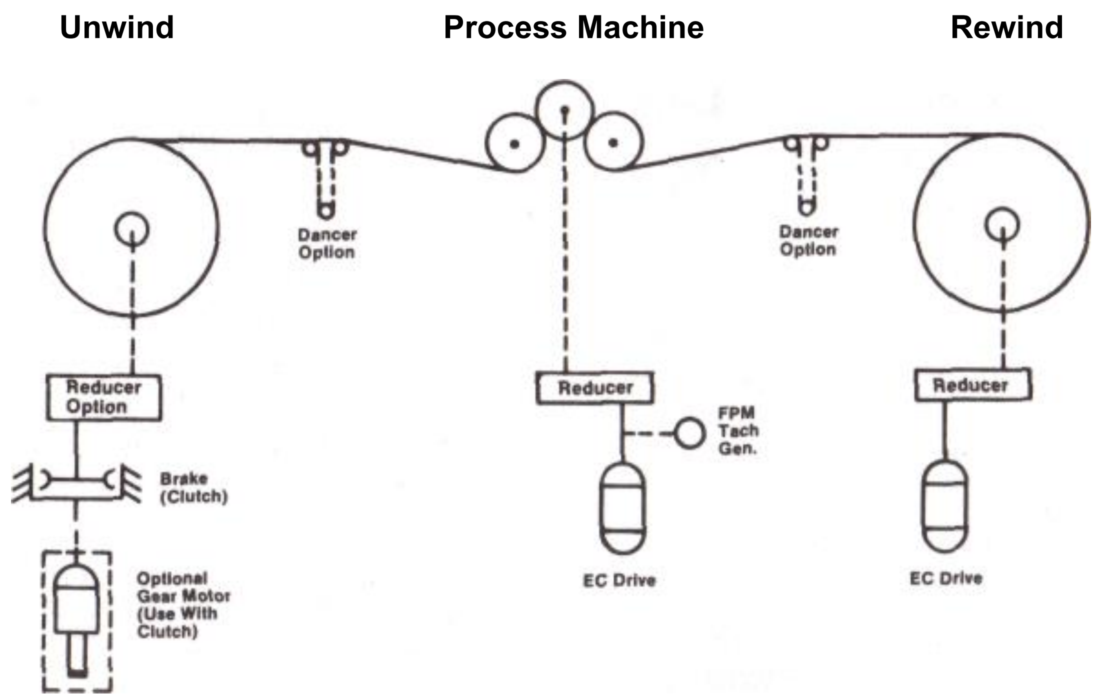
TYPICAL COATED WEB SYSTEM

Centerwinds are, therefore, constant horsepower applications. In theory, any electrical, hydraulic or mechanical drive that can deliver constant horsepower *could* function as a centerwind drive. Other variables on the average machine rule out many of these drives. Some of these variables are:

1. Variable FPM
2. Wide Tension Range
3. Wide Speed Range
4. Tapered Tension
5. Speed Transients
6. High Maintenance
7. Tension Accuracy Requirements

Other important information includes:

8. Variable Inertias
9. Large Buildup Rations
10. Economics



To properly apply drives to centerwinders, certain basic information is required, such as:

1. V – Maximum and minimum machine FPM
2. F. – Maximum and minimum tension in Lbs. per inch.
3. W – Maximum and minimum width of web
4. D_o – Maximum full roll diameter
5. D_c – Minimum core stock OD
6. P_s – Power (strip)

7. P_m – Power (motor)

Other important information includes:

1. Density of material
2. Maximum and minimum thickness
3. Acceleration and deceleration rates of material
4. Main drive breakaway characteristics
5. Thread and/or job speed
6. Operating sequence

To size and Eddy-Current drive for a centerwind, the following formula may be used:

$$P_s = \frac{VFW}{33{,}000} = \text{strip HP}$$

$$Pm = \frac{P_s \times D_o}{D_c} = \text{Motor HP}$$

Consideration should be given for friction losses and acceleration of maximum winder inertia.

If tension is to be tapered, the above motor horsepower can be divided by the taper ratio to arrive at drive size.

Full thermal capabilities are normally required of the drive since the winder may be stalled (zero FPM) and yet provide full tension at approximately full roll diameter. The drive must then provide maximum rated torque at zero RPM. On larger winders, this may require liquid-cooled, Eddy-Current units.

Once the drive unit has been determined, the proper reduction ratio must be calculated. The maximum rations will equal:

$$\frac{N_d \times D_c}{V \times 3.82} = ?:1$$

Where Nd is the maximum rated drive output speed and 3.82 is $12 \div \pi$.

At this time, it should be determined whether braking is desired or required. If so, either an Eddy-Current brake or a friction brake must be added to the mechanical unit.

The next and often difficult part of centerwind applications is determining the type of controller to use. Several type are available, and which one is chosen depends on the variables listed above, the material being wound, and the process involved.

Three basic factors must be kept in mind:

1. In a system, something must regulate FPM, and something must regulate tension. A given controller and drive, at a given moment, can regulate either speed or tension (torque) – never both.

2. The FPM of the system must be positively controlled at all times – from stalled conditions through breakaway and acceleration, at steady-state speeds and through deceleration back to stalled conditions. A tension-controlled winder must have something to pull against. The line speed setter must be able to hold FPM regardless of design tensions at the winder.

3. A winder drive must always supply enough torque to overcome losses with a surplus for tension. Unless the centerwinder is a constant FPM centerwind (described below), it can do nothing relative to setting RPM. The winder RPM is dictated by the FPM and the roll diameter at any instant. It is, therefore, often more desirable

to think in terms of winder torque and diameter than in terms of RPM.

In the case of simple slitters, embossers, coasters, inspection winders, etc., it is often possible to use a constant FPM centerwind. The centerwind sets line speed. The controller would be the common main drive type, incorporating such features as jogging, threading, controlled acceleration, and braking. Instead of using tachometer feedback from the winder drive itself (which represents winder RPM), a strip generator would be used (which represents FPM). The FPM would then be held constant, regardless of the changing roll diameter. Tension must be set elsewhere in such a system.

Those applications which require a minimum of accuracy and a minimum cost can often be accommodated by use of a simple “clutch motor”. Under these circumstances, a fixed value of excitation is set for a clutch coil. As the roll diameter increases, the torque being delivered would be that which the inherent torque/speed curve of the drive would provide. Such a winder setup would normally provide a sizeable degree of tension tapering as the roll diameter increases. For all practical purposes, on the average installation, winding would be accomplished at constant torque rather than constant horsepower. The taper ration would approximate the buildup ratio.

Another economical method of approaching constant horsepower would be the use of what is commonly called straight-line tension. Such a controller is essentially a speed control with extremely poor regulation. Thus, as the winding roll diameter increases, the clutch would be forced to decrease in RPM. This increase in slip would provide an increased torque due to controller speed regulation, even though the regulation is poor. By proper adjustment, the drive can slip back sufficiently to wind a full roll without the torque becoming exorbitant. With this type of winder control, the tension would tend to be light at the beginning of the roll, heavy in mid-roll, and, again, light at the full diameter. With a buildup ration of 2 ½ to 1, the maximum tension error would be approximately 7%. If greater buildups are used, this error grows accordingly. Tapering the tension, however, tends to reduce the errors. Taper adjustment is normally inherent to the controller.

All constant tension or tapered tension centerwinds have one thing in common, and that is the requirement of measuring or simulating the diameter continuously. In as much as the essential item being controlled is motor torque, the radius of the roll must be always known. Then the proper torque can be determined by the logic circuitry to produce the desired tension. As stated above, the torque must increase directly with diameter increase. This can be accomplished by using a rider roll or lay-on roll operated potentiometer to adjust the torque of the drive. This potentiometer would swing the torque from a preset core value to a preset full roll value. The major disadvantage of this system is the nuisance value of the rider roll. Tapering the tension of a rider roll or lay-on roll potentiometer type of rewind is accomplished simply by setting the proper full roll diameter torque in the controller.

When relatively narrow webs are involved and contact with the surface of the material is allowed, it is often highly desirable to use a dancer position control on a centerwind. This method of control is probably the most accurate of all forms of tension control. If the sides of the dancer loop are approximately parallel, the mass of the dancer assembly is made as low as possible, and there is a minimum of friction or resistance to the dancer travel, then changes in dancer position would have minimal effect on the webs tension. With such a controller, it is necessary to mount a feedback potentiometer on the dancer assembly such that its resistance is proportional to the dancer position. This feedback information (which is position information) is compared to a regulated reference voltage in such a manner as to supply sufficient torque to hold the dancer in the preset position. Inasmuch as the controller is a proportional band controller, any change in dancer position due to roll buildup would be extremely small. The amount of change required to compensate for buildup torque chances would depend upon the gain of the controller. In addition to the above-described reference circuit and dancer feedback circuit, rate circuits are required for stability.

Dancer position controlled centerwinds may be used when a very high torque ration or high-speed ratio is required. Other forms of tension control incur significant errors at very low speeds and torques. Inasmuch as the actual web tension is determined by the effective “weight” on the dancer assembly, the winder does not actually regulate tension. Its fundamental function is to wind material at the same feet per minute as it is being delivered by the process machine. It is usually desirable to load the dancer with adjustable, regulated air pressure, since this method contributes a minimum of mass to the dancer assembly. The air pressure regulator is then used as the tension-setting device. It is necessary, however, to use an air pressure regulator system capable of relatively high air flow rates to be sure there will be no restriction or “dash-pot” effect. Such practices as using counterweights and/or shock absorbers are detrimental to maintaining the most desirable tension accuracy under transient conditions.

A dancer position control, as so far described, will provide constant tension only. To taper the tension on a dancer-controlled centerwind, it is necessary to change the effective “weight” of the dancer as a function of roll diameter.

This is accomplished by tapering the air pressure as a function of roll diameter. This utilizes a radius generator circuit (described below) to determine diameter and a voltage to air pressure converter to load the dancer.

The most recent tension controller for centerwinds (and unwinds) makes use of a radius generator circuit. It utilizes FPM information from the line speed setter (or strip generator) and core shaft RPM from the winder tach generator to calculate roll radius continually. The result of the calculation is DC voltage that varies linearly from 1 volt to 10 volts as the roll grows from core diameter to ten times core diameter. These 1 to 10 volts are then used as a reference voltage for a constant current controller (clutch motor or torque regulator). Any buildup ratios less than 10:1 are automatically accommodated. Greater build up rations can be accommodated by proper setup.

The overall speed range is 1600/40 RPM. At winder drive RPMs below 40 RPM, the controller automatically goes into a stall tension mode. Field adjustments are as follows:

1. Stall tension (a function of set tension).
2. FPM
3. Inertia compensation
4. Friction compensation
5. Breakaway pulse
6. Taper

The taper is infinitely adjustable from constant tension to constant torque. Constant tension is constant horsepower, constant torque results in taper ratio equal to the buildup ration.

The taper and/or the stall potentiometers can be mounted either in the control enclosure or at the operator's station.

The radius generator circuit is on a separate printed circuit board and can be used with a Model 4050 or Mark III Eddy-Current controller.

Although the above covers the main points relative to Eddy-Current centerwinds, it does not cover all possibilities. There are other variations which Dynamatic® application engineers have addressed. Some of these are:

1. Slipping core differential winders
2. Dual duplex differential winders
3. Ajusto-Spede®/Variator rewinds
4. Turret rewinds
5. Unwind stands

Please contact Dynamatic® to discuss your tension/winding application.