

Paper Machine Winder Tension Control Performance



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Unwinding Web/Strip Tension Control is a very critical aspect of PM Winder operations, and has a significant impact on the quality of;

- o Slitting
- o Slit Sheet Width
- o Set Roll Density
- o Set Roll Edge Trueness

Allen Bradley Pulp & Paper Drive Systems operations, based on its many years of experience at applying drive systems for the control of Speed, Torque, Power, and Tension within PM Winders, is very appreciative and knowledgeable about the specific issues related to successful Winding & Building of high quality Set Rolls.

Web tension transduction is typically incorporated within the machine frame mounting apparatus of a transport roll in the slitting area of the winder. This force/tension signal is used as feedback to the Programmed Torque control of the Unwind Drive, to provide variable torque trim, such that Web Tension is maintained accurately relative to set point, when the Winder is in the Run mode of operation. Closed Loop Tension Control is typically not incorporated in the Stall, Thread, Set Change, and Splice modes of operation due to the significant machine apparatus induced web disturbances associated with the respective operations,

Per the statements above, tension control within particular value limits is certainly of importance relative to building quality rolls. And therefore, both the robustness of the Unwind Drive control strategies and the drive's ability to deliver smooth and calibrated motor/generator shaft torque are critical to accomplishing the above.

Motor / Generator Shaft Torque Delivery

Allen Bradley's 1336-T ISOFOC AC Drive and 1395 DC Drive are both laboratory and application proven, leading the drive system industry in providing both smooth and accurate delivery of motor shaft torque throughout the complete speed range of the particular application.

PM Winder Control Strategies

Unwind Diameter Calculation

Continuous Digital Calculation of Unwinding Diameter to provide knowledge of the existing moment of the Unwinding Stock Roll for establishing;

- o Torque relative to Tension and Radius
- o Volume of Paper Stock for Stock Roll density
- o Radius of gyration for Accel/Decel torque compensation

Knowledge Based Feedforward Torque Control

Implementation of thorough and accurate Feedforward Torque control strategies, such that the span of control necessary from the **Outer Closed Loop Tension Regulator** can be significantly reduced, allowing for appreciably more accurate and responsive Web Tension Control.

Also, due to the effectiveness of these control strategies, Allen Bradley driven PM Winders are always able to operate successfully and build saleable Set Rolls without the availability of Web Tension Feedback.

Closed Loop Tension Regulation

Based on the Feedback from the above referenced Tension/Force transducer roll assembly, Allen Bradley incorporates industry leading control strategies for accomplishing;

- o operator independent automatic transitions from Unwind Thread and/or Maneuver Speed modes of operation to the Unwind Stall Tension mode.
- o bumpless transitions between Stall Tension mode and Run mode operations.
- o very accurate and drift free Web Tension Control in the Run mode.

Per the above, Allen Bradley's PM Winder Drive Systems are configured to be the primary tool for effecting both smooth and accurate Web Tension control. However, relative to specifying degrees of accuracy which can be expected for a specific application, a number of Machine and Paper Stock issues must also be taken into consideration. Often these issues have significant impact on realizing the final limitations of Web Tension variability. These issues are:

Tension Transduction

- o The quality of the Force Transducer Product itself which is incorporated within the particular Tension Roll assembly.

- o Total Maximum Force Range Capacity of the selected Transducer devices:

If the Maximum Force Range Capacity of the Transducer devices selected is significantly greater than the particular application will realize, then the Mechanical-to-Electrical Transduction Signal-to-Noise Ratio will be negatively effected.

- o Number of Cross Machine Tension Roll Assembly Support Points which are Force Transduced:

For a number of reasons, (resolution, optional control, and redundancy) the more Cross Machine Support Points Transduced the better. Machine width and associated economics will of course limit the number of transducers employed.

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Two(2); one(1) on the tending side and one(1) on the drive side are considered minimal.

Because Stock Sheet Characteristics are often relatively poor at the extreme tending and drive sides of the machine, the most optimal combination is Five(5) Transducible Support Points across the machine. The Three(3) inboard Support Points are Force Transduced and employed as averaged Web Tension Feedback to the Unwind Drive Torque Control system.

The two(2) remaining Outboard Support Points can either be non-transducer supported or be force transduced for display of Tending & Drive Side Sheet Conditions.

This Inboard / Outboard approach removes the often significant Edge Tension variables from the Web Tension Feedback Signal, yielding the potential for higher performance Closed Loop Tension Control.

- o Sheet Wrap Angle around the Tension Transducer Roll Assembly:

The Sheet Wrap angle is normally dependent on the sheet transport geometry limitations in the Slitting area of the Winder . However, it is important to realize that the magnitude of the Force Vector imposed on the Tension/Force Transducer by the Sheet Tension/Force is directly proportional to the amount of sheet wrap around the transport roll. Therefore this also directly effects the Sheet Force-to-Tension Transducer Output and the associated Mechanical Signal-to-Noise Ratio. The less the sheet wrap angle, the lower the translation of Sheet Tension Force to the Roll Support Force Transducer. Consequently the non-tension mechanical forces due to machine and roll imperfections will have a relatively greater influence on the Tension Transducer output than the actual Sheet Tension vector. ie a poorer mechanical-to-electrical signal to noise ratio.

- o Quality of the Tension Transducer Roll Assembly:

Per the above item, machine and transducer roll mechanical imperfections are translated to the roll support force transducers. These undesired components of transduced force are effectively Mechanical Noises, and it is critical that they are at minimum in order to realize smooth and accurate tension control.

The primary point relative to all of the above Tension Transduction issues is that the Unwind Drive System's ability to control sheet tension, like all closed loop controls, is first limited by the quality of the Feedback (Roll Forces) as it relates to the parameter being controlled (Web Tension).

Winder Mechanical In-drives

The Speed and Torque delivery characteristics of the Winder Mechanical In-drives has a substantial influence on the quality of Web Tension Control.

The Unwind Motor/Generator in-drive coupling and shafting must have minimal compliance and backlash because its shaft torque is being proportionately and accurately regulated to effect desired web tension.

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The In-drives of all sections of the Winder must also have minimal compliance and backlash and have high enough natural frequencies such that they do not degrade the dynamic performance of the speed regulated sections.

The Speed Regulated Drum (typically the Rear Drum) should have the shorter in-drive shafting if motors are required to be physically staggered. This is desirable because the Speed Regulated in-drive should have the stiffer torsional characteristics.

Web Transport From Unwind > to > Tension Roll > to > Drums

Winder sheet transport rolls which have potential negative influences on Winder Web Tension are:

- o Guide and/or Lead In Rolls
- o Paper / Sheet Transport Rolls
- o Spreader Rolls

The above Web Transport Rolls, driven or undriven, have the potential to influence sheet forces in the same sheet span that the Web Tension is being transduced. Also, most of these rolls are situated in the web path, between the Tension Transducer, and the torque regulated Unwind Drive responsible for effecting Web Tension Control. To reduce the potential negative influences that these transport rolls may have on sheet tension, a number of the following considerations should be considered:

- o Improved roll frictional losses and dynamic stability
- o Reduced Roll Surface to Sheet Surface Friction/Drag
- o Drive all transport Rolls

Sheet Weight and Related Tension

Light weight sheets, typically wound at lower maximum tensions, significantly complicate meeting percentage based tension specifications. Therefore this places far more emphasis on all of the above issues being optimized.

For these applications, the Unwind Drive Torque component effecting the Web Tension component becomes a significantly smaller portion of the combination of non-tension Torque components. That is:

- o The absolute negative influence of Frictional and Sheet Transport Forces remain appreciably the same for winders of lighter/lower-tension sheets as for heavier/higher-tension sheets. Therefore, as a percentage of total operating tension, the torque for tension control becomes significantly smaller, and machine and roll imperfections have a far greater negative influence as a percentage of operating Tension.

- o Stock Roll inertia, which also has a negative influence on the Winding Tension component of torque during acceleration and deceleration, typically increases with lighter weight sheet stocks due to the tendency to realize more densely wound stock rolls. Therefore, the difficulties relative to compensating for inertia induced

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Tension deviations during acceleration and deceleration, and their potential negative influence as a percentage of the Web Tension component of Unwind Torque, impose a dual negative effect.

The above discussion is limited to Winder Machine and Drive issues, and assumes that the structural quality of the Stock Rolls of Paper delivered to the Winder are sound.

It is understood that if the Unwind Stick Rolls are of poor quality such as;

- o out-of-round,
- o greatly varying density
- o uncharacteristically soft
- o greatly varying edge trueness

that meeting particular tension regulation specifications is not expected.

Per all of the above, the Tension Control Requirements listed in:

Customer or OEM Specification area

are marginally attainable only if the above referenced issues are adequately addressed such that the respective negative sheet tension influences are kept to minimum levels consistent with industry standards for winding **News Print** Sheets.

In the final analysis, it is the Allen Bradley Pulp & Paper Drive Systems Business's position that the criteria for judging adequate Winder Web Tension Control is in the noticeable and/or measurable effect that Operational Web Tension has on

- o Slitting
- o Slit Sheet Width
- o Set Roll Density
- o Set Roll Edge Trueness
- o General Set Roll Quality

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