Integrating the Process. . .

The Future of Calender Control

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The Future of Calender Control: Integrated Gauging and Overall Line Control

Introduction

In the increasingly global and competitive marketplace, tire manufacturers today are constantly searching for ways to maximize both productivity and quality. One approach to tackling this complex issue is to unify the calendering process. This is accomplished by integrating control of the entire process, rather than the historical approach of having stand alone controls for different areas of the process such as drives, gauge control, and temperature control. Integrated control of the calendering process presents the opportunity to optimize quality, manpower, raw material usage and process information management.

An Integrated Process Control System controls all process and product parameters as well as coordinating all subsystems as a single integrated entity. The gauge control function becomes an integral part of controlling the total process. This includes control of speed, tension, sequence, width, and centering for the calendered web from let-off through wind-up. This article will present the various parameters that are typically controlled in the calendering process and then discuss the advantages of the 'Total Process Control' approach for the calendering process.

Control and Coordination

Major Line Parameters to be Controlled:

- **Gauge**
  - Thickness
  - mass per unit area, e.g. grams per square meter or gsm
  - assembled fabric gauge balance
- **Roll speeds and ratios**
  - individual roll drives permits roll ratios optimized for the specific product
- **Line speed**
- **Pre-Calender tension**
- **Post Calender tension**
- **Let-off accumulator position**
- **Wind-up accumulator position**
- **Line logic**
- **Let-off logic/sequence control**
- **Wind-up logic/sequence control**
- **Width control**

Major Line Parameters to be Controlled Continued:

- **Centering and Guiding control – Pre & Post Calender**
- **Feed system control**
- **Bank height compensation and/or control**
- **Cushion or Assembly force control**
    - water side and drive side compensation
    - speed compensation
- **Roll straightening/bending control**
    - center gauge control
    - compensation for roll deflection at the center for both gauging and assembly nips
- **Cross Axis control**
    - center gauge control
- **Screw down or hydraulic down actuators for gauging roll end control**
- **Screw down or hydraulic down actuators for cushion or assembly roll end control**
- **Roll temperature control**
- **Cooling drum temperature control**

All these parameters are interrelated. For example, calender speed affects roll straightening and cushion assembly force requirements, as well as bank height and feed rate requirements. The bank height in turn affects roll separating forces and therefore roll straightening or cross axis requirements as well as frame stretch which alters the gauge. The change in final web width at the wind-up compared to the width immediately after the calender alters the effective calendered gauge. A single integrated system that co-ordinates all these variables in a smooth and transparent manner for the operator is therefore called for if quality and productivity objectives are to be achieved.

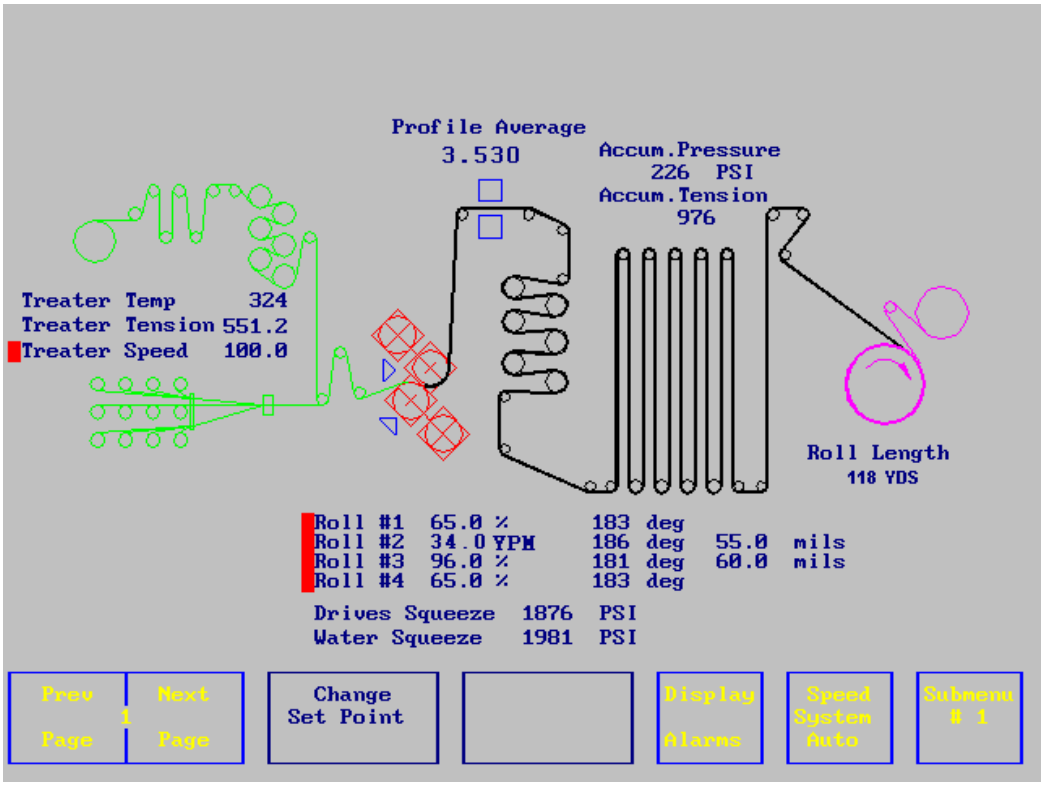
Unified Operator Interface & Centralized Product Set-Up

All the parameters for the gauging and line control should be coordinated at recipe or product code change. Having multiple separate systems that the operator must be sure to individually co-ordinate is an invitation for human error. Errors can be very costly, particularly if undiscovered until the end of a run or even worse, after the calendered material has been incorporated into a large number of tires.

Selecting the new product to be run from a list of product codes that loads preset set points for all line parameters eliminates the chance of error and permits the operator to focus on the process. Increasingly tire and rubber companies want to manage process parameters for all major process at a central location, typically a mainframe computer such as an IBM AS400. These are to be downloaded on demand to set up the entire process. This assures that the latest specification is utilized and minimizes the chance of human error. It also facilities revision history maintenance. Interfacing a single integrated system for each major process, such as calendering, mixing, and extrusion, is much

more cost effective, reliable, and easier to support than attempting to tie multiple dissimilar systems together.

Likewise, providing the operator a unified operator interface that presents all the key process parameters simplifies the operator's job and improves overall control of the process. The operator can view trend plots of product gauge, temperatures, roll ratios, assembly pressures, line speed, etc. so that process upsets and their cause are much more easily identified and understood.



Typical Integrated Calender Control Operator Interface
Touch the piece of equipment to zoom in for detailed control & monitoring

Data Collection & Analysis

Process and productivity data collection for real time and historical analysis is generally a requirement in today's market. This data is best obtained as a by-product of process automation rather than as a separate stand-alone system. Stand-alone data acquisition systems typically approach the cost of full process control while having lower accuracy and requiring increased support. This is because qualifying the data is difficult. A full process control system would inherently know when the process is running, when it is producing versus running empty to warm-up, when it is on specification, what the process parameter target set points are, and what actions the operator is taking. This information is necessary to correctly interpret data that is collected but difficult to obtain for a stand alone-data acquisition system.

Freedom to Select the Best Technology for the Job

True Integrated Calender Control means being able to make use of the best control and gauge measurement technology for the application and smoothly integrating or marrying these all together in a system that performs well and provides the end customer with:

- **Ease of operation with minimal effort**
- **Low initial cost**
- **Upgradable to assure long life and avoid obsolescence**
- **Unified operator interface**
- **Accurate gauge control**
- **Low cost of ownership**
- **Easy low cost maintenance by end customer**
- **Precise control of speed and tension**

The Integrated Calender Control approach should also address the need to combine other control systems by other equipment system suppliers such as a PLC that may come as a standard part of a wind-up with the primary line control system. Why re-engineer or change the hardware and/or software just to standardize? This is costly and makes support by the equipment supplier much more difficult. A good Integrated Calender Control system should be able to seamlessly tie together multiple different PLCs and other vendor computer systems. It is always desirable to have a single make and model to simplify maintenance, but this may be cost prohibitive and preclude taking advantage of future developments and product improvements by the equipment supplier.

PLCs are well suited for line logic and sequence control such as need for complex wind-up systems.

Gauge control is best done by computer based systems and should be a function of the overall line control system to handle:

- **Extensive high speed mathematical calculations**
- **Decoupling of gauge correction interactions**
- **Speed Comp for cushion/assembly pressure**
- **Transport lag comp**
- **Gauge interfaces that may involve extensive communications**

Gauge Measurement covers a wide range of technologies and the overall control system should provide support for these from a range of vendors. These include on-calender and post calender measurements. The actual measurement may be based on any of the following technologies or combination of technologies:

- **Eddy Current**
- **LASER**
- **Capacitance**
- **Nuclear back scatter**
- **Nuclear transmission**

Line speed coordination can be handled by either computer based or PLC based systems.

Width and Centering control are based on dedicated computer systems or handled by the main line control computer system.

Data collection and analysis is handled by the overall line control computer system since it has access to all line parameters and operator activities. The overall line computer may also be linked to a central host computer that provides a central point for data collection and historical analysis for multiple tire manufacturing processes. This central host typically provides multiple terminal access to the data and analysis via the customer's existing Local Area Network. The central host may also provide a link to the customer's main frame computer system. This permits scheduling downloads as well as upload and downloading of product recipe or setup data.

Other Benefits of Integrated Process Calender Control

Higher average line speeds are generally possible with an integrated control system that coordinates the entire process through the use of feed forward or anticipatory control techniques. Bank heights will be more stable, cushion or assembly forces, as well as cross axis and/or roll straightening, is automatically adjusted for all speed changes, and temperatures can be changed to match varying process conditions to give a few examples.

Reducing/Minimizing the labor content should be the goal and is achievable by an integrated approach that co-ordinates the feed systems (whether extruder, mill, or a combination), line speed and tension, let-off and wind-up operation, gauge control, and rubber bank management. This is accomplished by having the control system take anticipatory action based on changes in related process parameters. Furthermore the control system alerts the operator when necessary, thus freeing the operator from constantly monitoring the parts of the process that would otherwise require a major portion of his time.

Traceability and assurance of correct raw materials, as well as product and processing parameters usage during the process, is greatly improved by an integrated "Total Process" approach to calender control. Bar Code support for raw materials and finished material should be available as part of the system.

An Integrated Process Control System provides the operator with a unified process window, through which the operator can see and understand the many complex process relationships. Trend plots of all process parameters permit recognition of process parameter relationships that are otherwise impossible to see. Make the operator part of the process management and analysis team – the operator is on the front line.

Eliminate the isolated islands of automation. Why go to many different stations to set-up the process? The greater the number of stations to be set-up the higher the risk of human error. Additionally, why have multiple different data formats?

A good integrated process control system will eliminate the need to purchase expensive features such as SQC charting and graphic user/operator interfaces redundantly from multiple vendors.

Summary

An Integrated Process Control System should provide:

- **Precise control and co-ordination of <u>all</u> process parameters**
- **Overall process co-ordination**
- **Single point entry of product code to specify set points for <u>all</u> process parameters**
- **Data collection and analysis**
- **Support for mainframe product set-up download**
- **Production schedule download**
- **Central point for maintenance diagnostics and system alarm and event logs**
- **Process optimization**
- **Reduced material consumption**
- **Create audit trail**
- **Reduced operator-induced variability**
- **Flexibility to adapt to changing future requirements**
- **Unified process interface to help operator see and understand process relationship**

Benefits of an Integrated Process Control System:

- **Increased productivity**
- **Improved Quality**
- **Reduced man-power**
- **Faster changeover**
- **Reduced downtime**
- **Reduced material consumption**
- **Improved response to change of production schedule and product specification**

Conclusion:

An Integrated Process Control System should and can increase productivity, improve quality, reduce manpower, reduce material consumption, and improve response to changes to production schedules and product specifications. An Integrated Process Control System can also supply product, process, and production data to the rest of the organization in a meaningful format, on a timely basis, and in a cost effective manner.

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