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Solution Delivery for High Precision Coating

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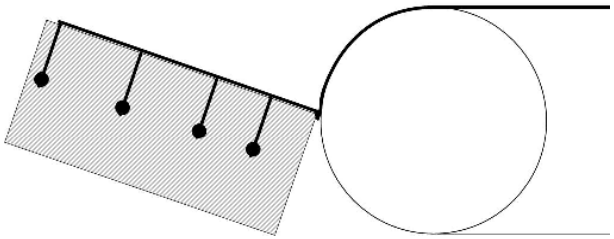
General Functions of a Coating Process

- Distribution of Liquid in Cross-Web Direction
- Deposition of Liquid on Substrate
- Control of Coating Thickness in Down-Web Direction

Solution Delivery System has significant influence on all of these key functions.

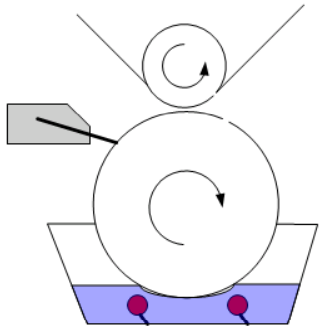
Pre-metered vs. Self-metered Coating Methods

Pre-Metered (Curtain, Slide, Slot)



- Coating thickness determined by fluid metering means upstream of coater.

Self-Metered (Gravure, Forward-Roll, Knife)



- Coating thickness determined by interactions between fluid and coating device.

Solution Delivery System Requirements

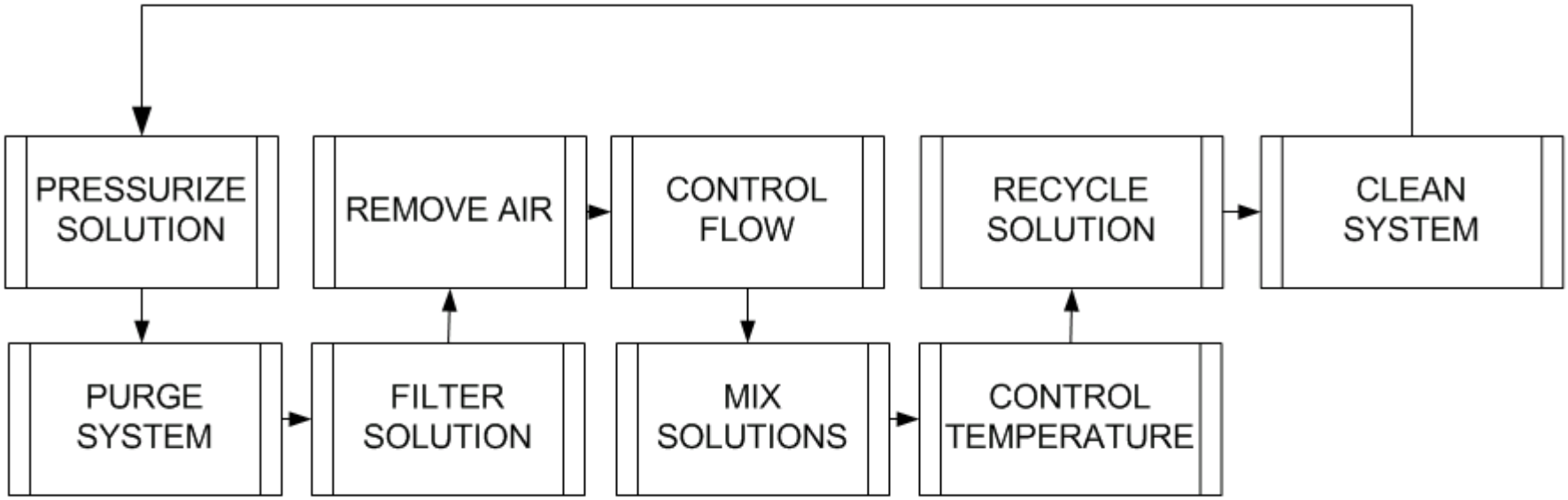
- Supply solution free of contaminants
- Provide accurate flow rate over range of flow rates
- Provide homogeneous solution (settling, mixing, purging)
- Control Temperature/Viscosity
- Maintain delivery system cleanliness
- Accommodate machine stops/starts with minimum waste
- Minimize product changeover times

Understanding Coating Solution Properties

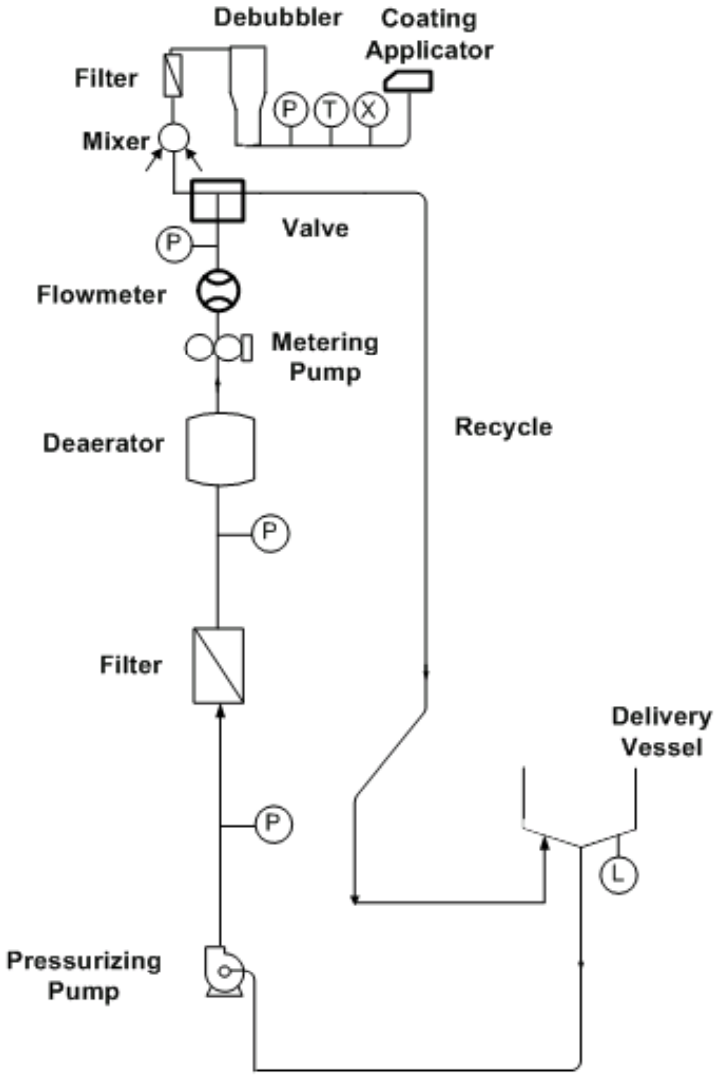
Key Parameters

- Rheology (viscosity vs. shear, elastic properties)
- Viscosity Stability (time, temperature)
- Solubility
- Propensity for Solid Particle Agglomeration
- Filtration Properties
- Cleaning Requirements

Process Flow Diagram



Solution Delivery System for Precision High Speed Curtain Coating



Pressurize Solution

Pressurization--provide driving force to allow solution to flow through system components.

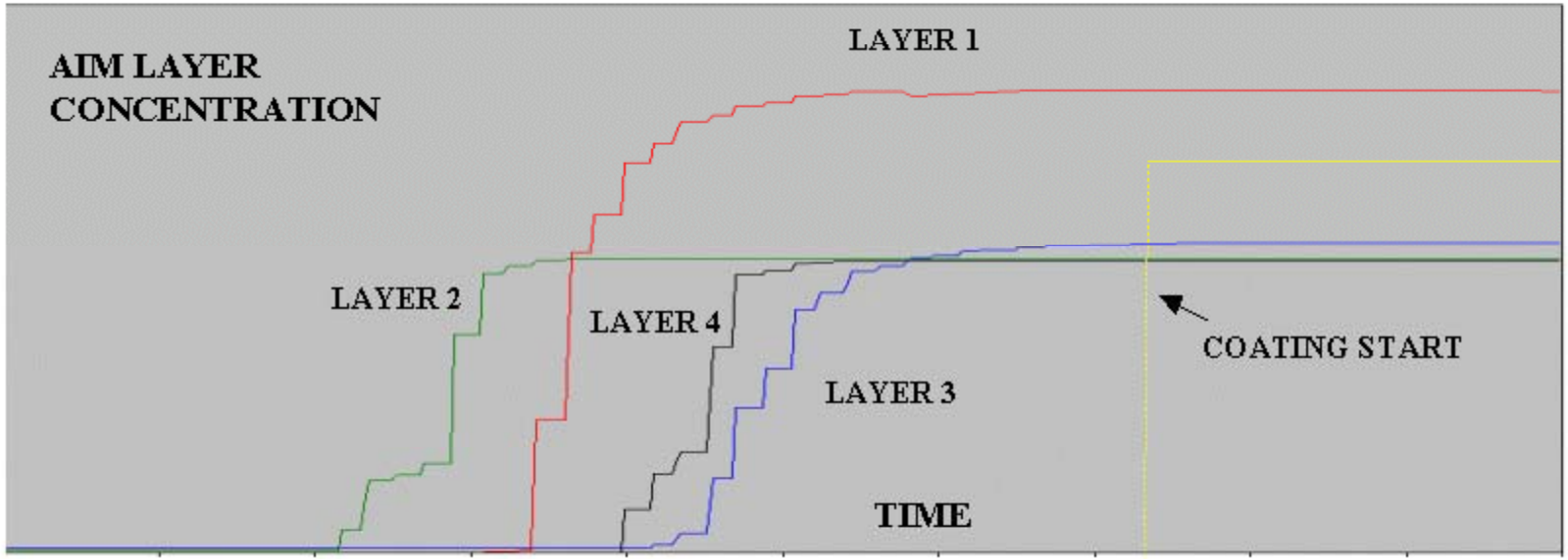
Critical Factors for Success

- Optimize delivery line ID and geometry (trade-off with system cleaning/purging)
- Knowledge of solution properties (rheology, flow rate)
- Pump selection
- Understanding of pressure drops through system components

Purge System

Remove cleaning solutions, air, and off-concentration product solution from delivery system prior to start of coating.

- Minimize product solution waste and purge time. Minimize system volume.
- Purging solution should be higher in viscosity and density than resident solution. Sequencing of in-line mixed components require special treatment.
- Pump up to aid in purging of air

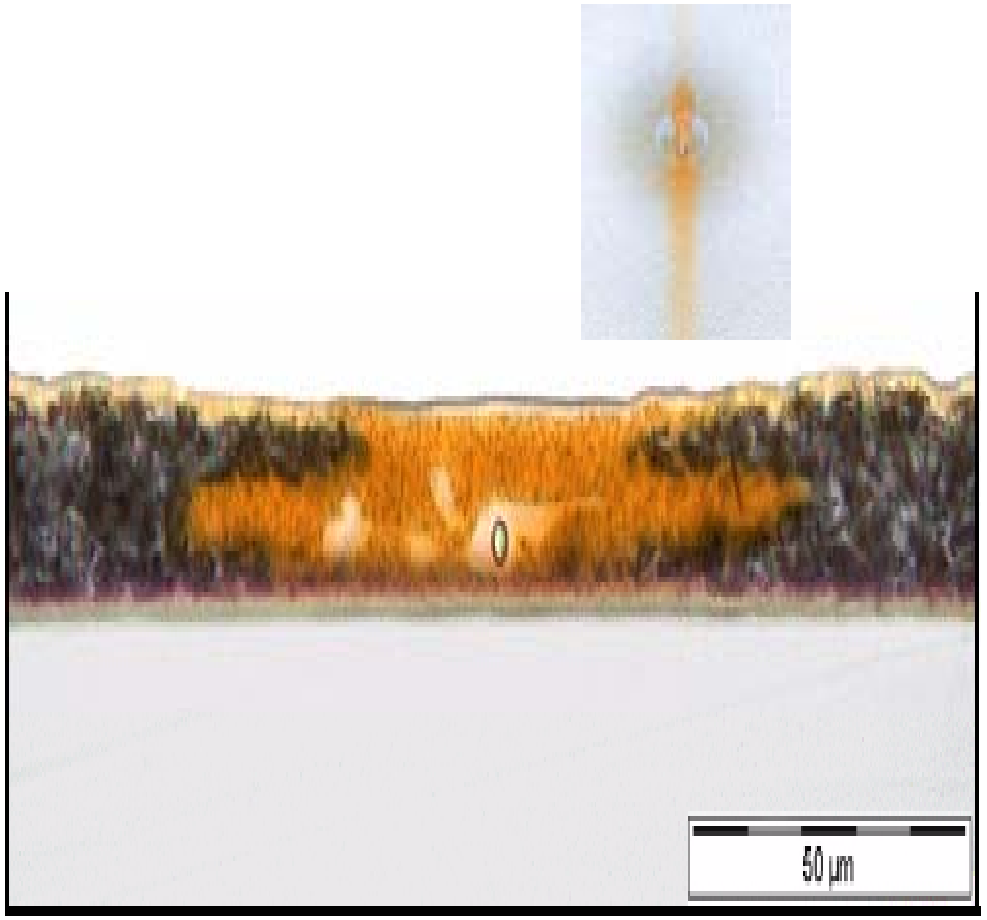


Filter Solution

Many options including rolled, cartridge, bag, disk, etc.

- Critical to run filtration tests prior to coating. Understand plugging rate, pressure drop, filtration effectiveness.
- Design and operation of filtration equipment must insure that no flow bypass occurs.
- Filter purging of air a concern, consider locating deaeration components downstream of filtration components.

Comet



Remove Air

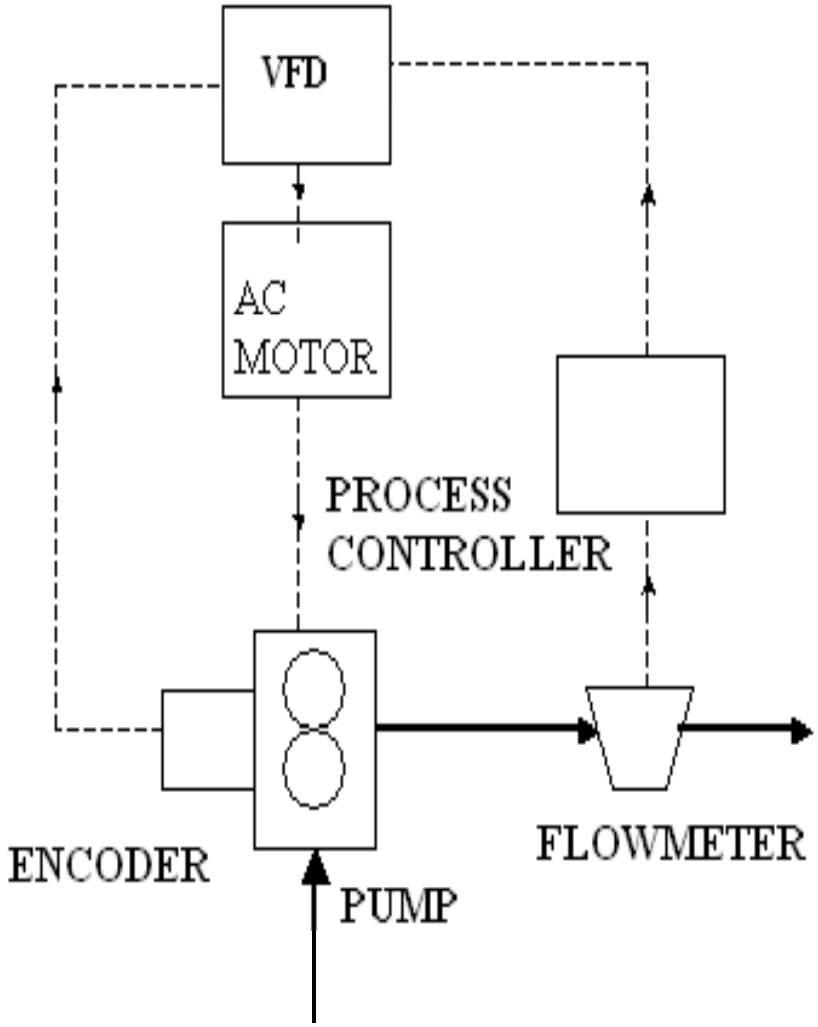
Entrained Air—Bubbles. Can cause lines and streaks and spot defects.

Dissolved Air—Air in solution. Can flash out of solution into bubbles.

- Optimize mixing and other upstream processes to avoid air entrainment.
- Avoid poor line geometries (loops, horizontal/downward sloping) that trap air bubbles or cause dissolved air to flash (abrupt changes in line diameter, direction).
- Minimize line diameter.
- Use staged approach to deaeration. First remove gross levels of entrained and dissolved air then supplement with debubbling device near coater for residual air levels.

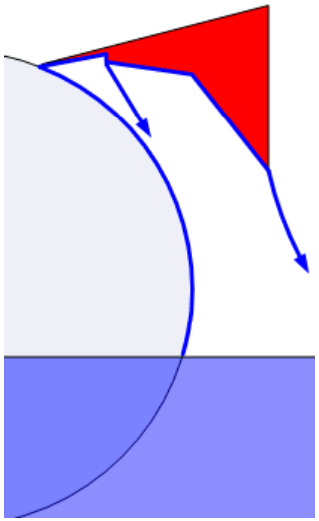
Control Flow—Pre-Metered Coating

- Use feedback control loop.
- Consider soft-walled delivery lines to absorb pressure pulsations.
- Pulsation dampening flow components may be necessary for critical applications.
- Monitor flow pulsations in frequency domain to identify root causes.

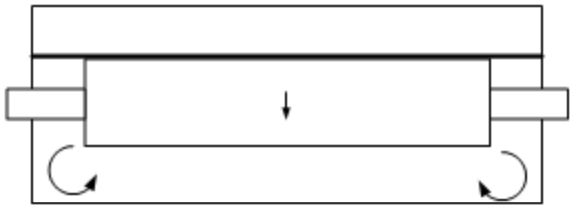


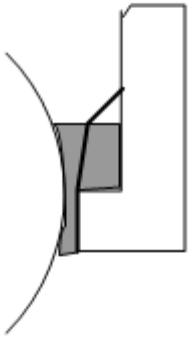
Flow Control—Self-Metered Coating

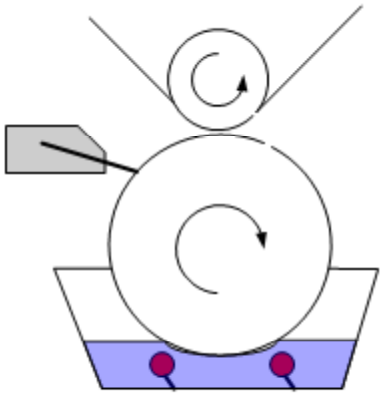
Gravure doctor blade fluid management



Gravure cylinder feed systems







Mix Solutions

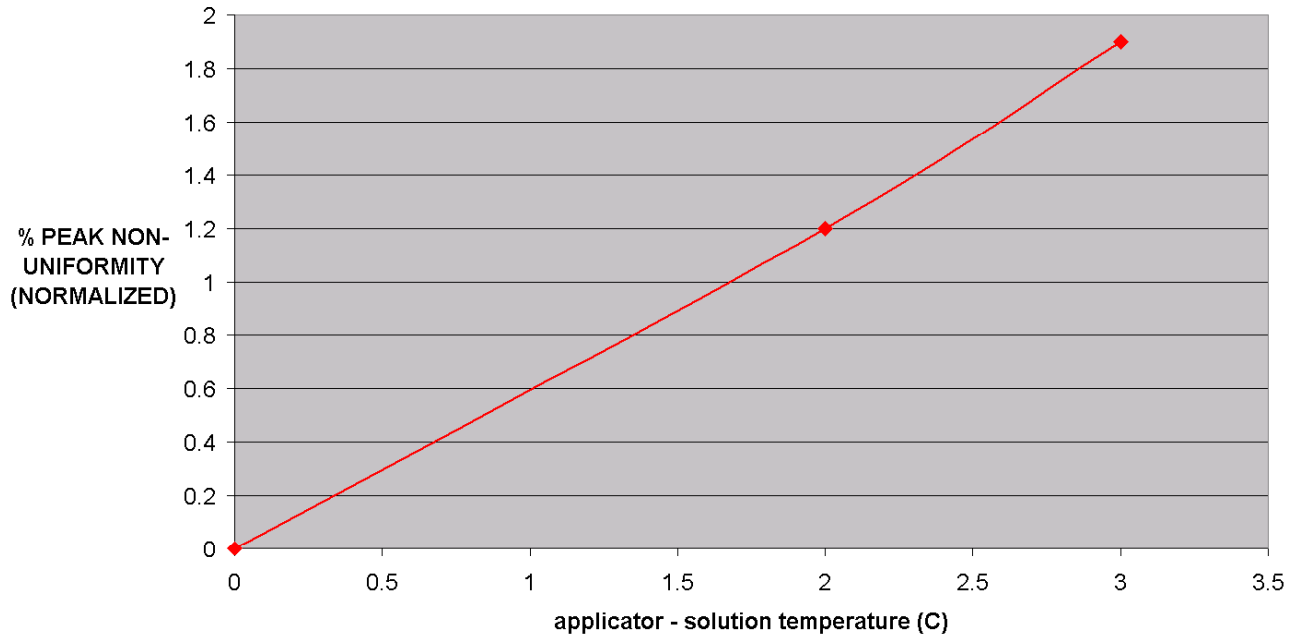
Insufficient mixing can cause longitudinal coating streaks

- Streaks from insufficient dynamic mixing change location and intensity with time
- Streaks from insufficient static mixing are in fixed locations
- Consult mixing data from mixer manufacturer although experimentation is sometimes required.
- Consider shear sensitivity of product solutions.

Control Temperature

Good coating solution temperature control (+/- 2 deg C) is needed to control solution viscosity.

- Ink viscosity control critical to printing press operation
- Non-isothermal operation of curtain/slide/slot coating applicator can lead to cross-web non-uniformities (smile, frown).



Clean System

Insufficient cleaning can lead to:

- Repellencies
- Lines / Streaks
- Functional product failure (i.e., inadequate curing, alignment, desensitization, etc.)
- Poor delivery system reliability (operational)
- Decreased filtration performance (higher costs)

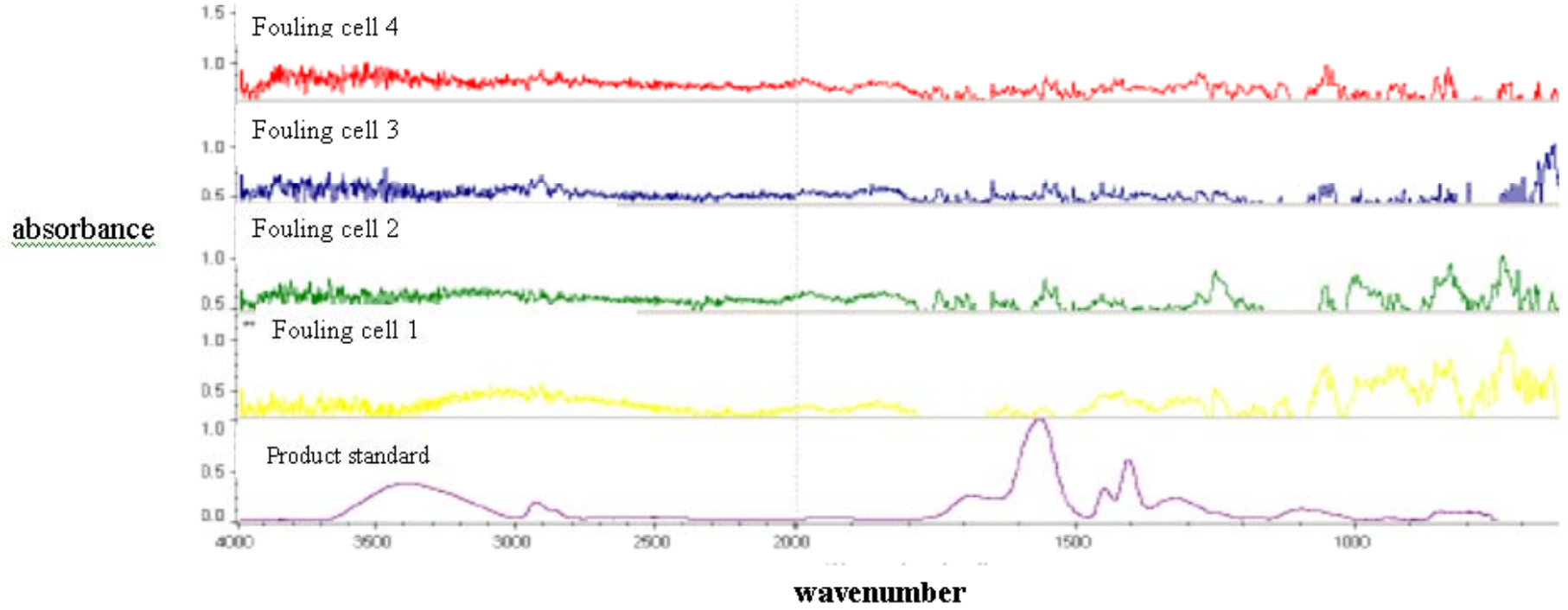
Cleaning Case Study—Using Lean Principles

Purpose: Minimize Product Changeover Time

- Shift internal activities to external
  - Filter set up external to product changeover time
- Eliminate, simplify, automate—in that order
  - Automated clean sequence to reduce operator-induced variability
- Determine how clean the system really needs to be
  - Use of fouling cell analysis to quantify cleaning effectiveness
- Standard work
  - Implemented and trained to JES documents based on new filter set up and automated cleaning sequences

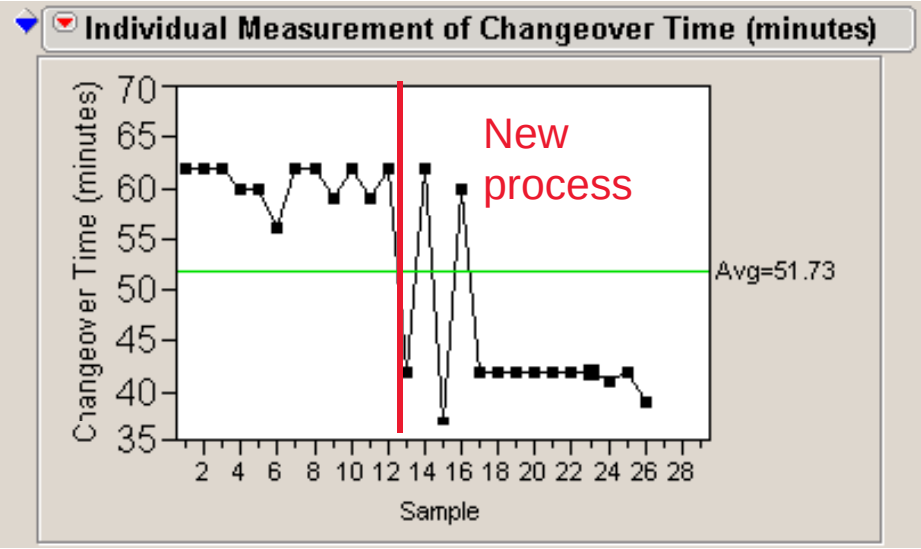
Delivery System Fouling Analysis

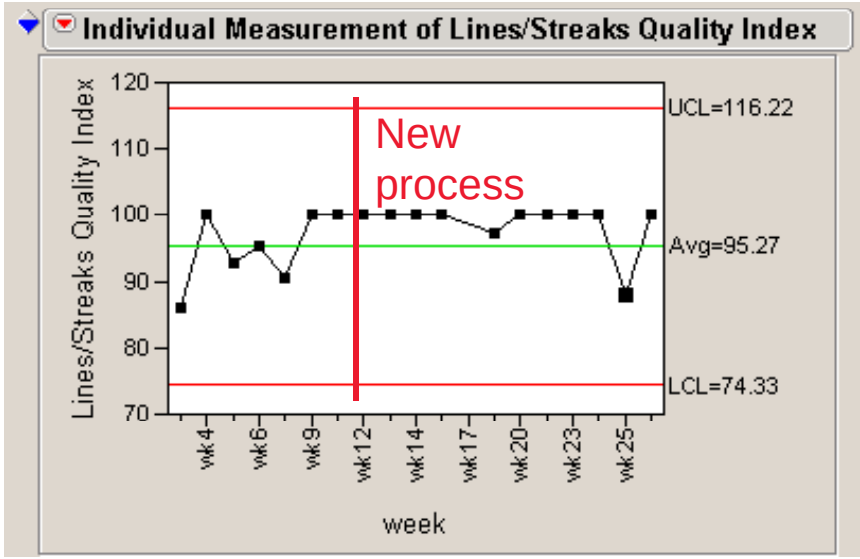
Use of fouling cells and FTIR (Reflectance Fourier Transform Infrared Spectrography) to quantify fouling propensity and cleaning effectiveness



Results of Case Study

- Reduced product changeover time by 20 minutes
- Did not affect product quality (lines / streaks performance)





High speed, high precision coating requires sophisticated solution delivery systems to accommodate product quality and cost requirements. Significant product/process understanding is required to insure smooth introduction of new products.

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