New Non-Nuclear Weight / Thickness Sensor for the Measurement and Automatic Profile Control of Extruded Film, Sheet and Coating

Eric J. Reber
Mahlo America, Inc.

eric.reber@mahloamerica.com
864-576-6288
Introduction

- The extruded film, sheet and die coating industry is always looking for ways to improve product quality while reducing scrap, minimizing raw material usage and providing value-added documentation to their customers.
- An online Web Gauging System with Automatic Profile Control (APC) is one of the best tools to achieve these goals.
- A newly developed Solid State NIR Sensor provides the real-time basis weight / thickness profile measurement without the use of rotating filter wheels or nuclear radiation.
- A fully intelligent auto-tuning Automatic Profile Control System closes the loop on the quality and financial improvements.
Most organic molecules have unique NIR absorption spectra

Band pass filters selected to measure the absorbed light intensity at the absorption peak of the molecule of interest (PET or PE for example) are used to obtain a measurement of the mass or thickness of the web component.

The more light that is absorbed at that molecule’s absorption wavelength, the more of those molecules are present in the web, and therefore the greater the weight or thickness of the web or web component (e.g. coating).
Existing NIR sensors utilize a halogen lamp, a Lead Sulfide (PbS) light detector, and a spinning wheel containing three, four or six filters.

- PbS detectors are quite temperature sensitive
- Rotating motors are subject to failure
- The time delay measuring the light through each filter in sequence can cause measurement errors with a moving web and scanning sensor
New Solid-State NIR Sensor (IMF-15)

- All Solid State – No longer dependent on spinning motors and modulated signals
- New ultra-high efficiency detection technology resolves 100x better than older devices
- Selectively measures the thickness and basis weight of a wide variety of film and sheet products
- Coatings and film layers are measured from a single location without the need for a subtractive system
- Selectively measures moisture in paper, nonwovens and coatings
- Reflection and Transmission Modes

Transmission and Reflection Modes Available
New Detector

- A new type of infrared detector, the Avalanche Photodetector (APD) has a higher quantum efficiency, lower dark current and an ultrafast time response relative to the formerly used (PbS) detector types.

- The much higher light sensitivity (~100x that of PbS detectors) means that an APD exhibits a much larger signal change for a very small target weight or thickness change, so the overall system gain is much lower, reducing temperature effects.

- Online standardization technique re-zeros the sensor when needed to eliminate any residual sources of drift that may result from dirt, aging, etc.
  - Also normalizes sensors to one another for easy field replacement without recalibration.

- The higher detector resolution expands both ends of the traditional filter wheel sensor’s measurement range to both lighter and heavier webs than previously available.
New Solid-State NIR Sensor

**Solid-State Array**

- Six detectors, each with its own discrete narrow band pass filter and a novel optical fiber light pipe provide true simultaneous same-spot measurements of all wavelengths with no light modulation.
- This results in very fast, stable measurement with 100x higher resolution than that of older spinning filter wheel devices.
- The use of an optical light pipe nearly parallel to the light source minimizes the effects of web flutter and can be configured with a small measurement spot for fine CD resolution. The six-filter array design also facilitates the selection of custom filters for special applications.
- With no motors or other moving parts to accommodate, the solid-state sensor design is much simplified, easing access for the user to replace the lamp with the sensor remaining mounted on the scanner.
Solid-State IMF-15 Sensor
Internal Components

- Fiber bundle
- 5W halogen lamp
- Detector block with 6 discrete filters and detectors
- Internal reference sample
Solid-State IMF-15 Sensor Components

- Internal Tile Standard
  - Used for Periodic Re-Zeroing and Normalizing Sensors
- Hard Borosilicate Glass Protective Lens
- Compressed Air Wipe
Solid-State IMF-15 Sensor
Online Scanning Measurement

- When used as part of an online scanning measurement system, the new solid state NIR Sensor (Model IMF-15) provides very fine CD resolution for accurate profile control and narrow defect detection.
- The new generation APD NIR detectors operate without special cooling up to 60°C (140°F).
Solid-State IMF-15 Sensor
Applications

- The new solid-state NIR Sensor measures the basis weight/ thickness of webs with high resolution, accuracy, and excellent defect detection.
- The six-filter design allows for the simultaneous measurement of many web components by a single sensor.
- The non-nuclear measurement technique is very selective and cost-effective and can be configured in either single-sided reflection, or dual-sided transmission modes.

**Typical Applications:**

- Single- and Multi-Layer Films
- Polymer Sheet
- Aqueous and other Organic Coatings
- Nonwovens
- Moisture
- Paper and Tissue
- Multiple Measurements Simultaneously
# IMF-15 Reflection and Transmission Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td>Basis Weight &amp; Moisture</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>IMF-R</td>
<td>IMF-T</td>
</tr>
<tr>
<td>Measuring principle</td>
<td>Reflection of infrared light</td>
<td>Transmission of infrared light</td>
</tr>
<tr>
<td>Measuring range Basis weight</td>
<td>Paper</td>
<td>~ 10 - 30</td>
</tr>
<tr>
<td></td>
<td>Polymer</td>
<td>~ 10 - 60</td>
</tr>
<tr>
<td>Measuring range Moisture</td>
<td>~ 0.2 - 15</td>
<td>~ 0.2 - 15</td>
</tr>
<tr>
<td></td>
<td>~ 0.2 - 10</td>
<td>~ 0.2 - 30</td>
</tr>
<tr>
<td>Measuring range Coating</td>
<td>0.2 - 200</td>
<td>-</td>
</tr>
<tr>
<td>Repeatability</td>
<td>Better than 1%</td>
<td></td>
</tr>
<tr>
<td>Measuring gap</td>
<td>10 / 15 / 30</td>
<td>10 / 15 / 30 / 60</td>
</tr>
<tr>
<td>Temperature range without cooling</td>
<td>10 - 50</td>
<td></td>
</tr>
</tbody>
</table>

1) Measuring range and measuring accuracy depending on the material (analysis of material samples necessary)
Automatic Die Profile Control System
for polymer film, sheet and extrusion coating

New Generation Automatic Die Control System

- An Auto-Profile Control (APC) System works in conjunction with an Automatic Die and will automatically adjust the die lip gap to produce a flat coating, film or sheet.

- A new 3rd generation APC System takes full advantage of research into a given die lip’s elastic modulus and thermal time constants to accelerate a flat profile after a startup, grade change or upset.

- Predictive algorithms are used for an automatic tuning feature which reduces setup time and takes the guesswork out of control coefficients.

- Advanced modeling tools for extrudate neck-in fully characterize any web distortion for fast and accurate control all the way to the edges of the web.

- Integrated diebolt failure detection utility continuously monitors each heater and immediately reports a fault condition in the die.
APC Features

- FAST START and KICK Modes for Rapid Control on Startup and Changeovers
- Independent PID Control of Diebolt Heating and Cooling
- Auto-Tuning
- Continuously Monitors for Diebolt Heater Failure
- Neighboring Die Bolt Compensation
- Predictive Non-Linear Neck-In Compensation
- Non-Flat Target Profile Shaping
- Comprehensive Recipe Management
- Compatible with all Autodies
Diebolt Profile Display Screens
Diebolt Profile & Heater
Linear Map Display
Diebolt Profile & Heater
2-Dimensional Trend

- Thick section of web at Diebolt 54
- Maximum Power at Diebolt 54

Thickness Trend
Bolt Power Trend
APC Diebolt Mapping Options

- **Inactive Channels** = Deckled Diebolts Entered in Recipe
- **Reference + Neck-in** = Auto-Calculates Deckle
- **1/1 Mapping** = Diebolts Always Referenced to Scanner
APC Diebolt Control Tuning

- Independent PID Control of DieBolt Heating and Cooling
APC FAST START

- Fast Time to Weight / Thickness Spec During Startup and Changeovers
- Provides Kick to overdrive Heaters for a Short Duration
- More Aggressive Neighboring Diebolt Compensation
- Control Adjustments after Every Scan starting with the very first
- Returns to steady-state control after a user-selectable time constant
- Scrap is reduced to the bare minimum and flatness is achieved in the shortest time

Typical Startup Time to flatness spec in 4.5 Minutes:
Standard with the APC System is Automatic Diebolt Heater Check which Measures for heater continuity upon startup and automatically at user-selectable intervals.

Not only does the APC detect and alarm in the case of a heater failure, it also identifies the specific bolt that has failed.

APC System compensates for the failed diebolt using its neighboring diebolt heaters until the fault is corrected.

Performed automatically and continuously.
Automatic Bump Tests for Accurate Mapping & AutoTuning

PID Parameter APC 1

KP = 0.064957, KI = 158.4, Tc = 226

KP = 0.036329, KI = 154.5, Tc = 221 s

Accept
Non-Flat Target Profile Shaping

Sections of the CD Profile can be set for:

- Thicker Edges for Orientation Frames
- Thicker Lanes for Slitting Knives
- Thinner Edges to Reduce Trimmed Scrap
Predictive Neck-In Mapping

- Amount and shape of neck-in & edge bead is dependent on a large number of Line, Die and Polymer parameters.
- The APC System incorporates non-linear neck-in algorithms which are determined for each product.
- Settings are stored in each product’s unique recipe.
APC System Hardware

- Compact yet laid out for easy access for wiring and testing
- Optional bulkhead connectors to die
“New Non-Nuclear Weight / Thickness Sensor for the Measurement and Automatic Profile Control of Extruded Film, Sheet and Coating”

- The extruded film, sheet and die coating industry is always looking for ways to improve product quality while reducing scrap, minimizing raw material usage and providing value-added documentation to their customers.

- The new Solid-State NIR Sensor will replace both older filter-wheel IR sensors and many nuclear gauges for a more accurate and cost-effective online measurement solution for polymer film, sheet and coatings.

- Where fully automated profile control is of interest, the small spot size and fast measurement capability of the Solid-State NIR Sensor is coupled with a 3rd Generation Autodie Profile Control System focused on a single goal: control the cross-machine profile to the flattest possible in the shortest amount of time and material.
Questions please!

“New Non-Nuclear Weight / Thickness Sensor for the Measurement and Automatic Profile Control of Extruded Film, Sheet and Coating”

by Eric J. Reber
Mahlo America, Inc.
Aimcal R2R USA Conference 2019
Myrtle Beach SC

Thank you