A novel QA approach to combined In-Line Defect/Pinhole detection and coating Opacity measurement.

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About Bobst.....

Bobst HQ – Mex, near Lausanne Switzerland

> Established in 1890
> Over 5,000 Employees worldwide
> 2 Main business areas Web Fed & Sheet Fed
Outline

> Introduction / Background
  > Application field
  > Customer’s requirements: Quality assurance versus productivity?
  > Types and sources of metalized defects
  > Why can a combined OD & Pinhole in-line monitoring system help?
  > Current types of inspection system
  > Optical Density and Pinhole measurement

> The proposed solution for OD and Pinhole monitoring
  > Main attributes
  > Probes assembly
  > Product performances
  > How to close the loop on metalizer?

> New perspectives of Quality assurance

> Conclusions
Introduction - Application field

Hawkeye for optical density & pinhole detection

GENERAL K5000 – film 8 – 120μm, paper 35 – 90 g/m², 1025 – 2025 to 2025 – 4050 mm, 1’000 m/min

Vacuum web coating & metalizing machinery for deposition of aluminium and clear barrier coatings for flexible substrates and special applications
**Introduction - Application field**

Hawkeye for optical density & pinhole detection

1. Pinhole detection
2. Optical density monitoring (0-4 OD)
3. USB data exportation for offline analysis
4. World wide remote control (optional)
5. Alarm array & Alarm stack
Background - Customer requirements
Hawkeye for optical density & pinhole detection

- Maximize the production speed without increasing defects.
- Produce the correct thickness of coating
- Measurable Quality
- Reduce Costs
  - Manpower (no need to monitor the machine during process)
  - Customer rejects
Background - **Types** and Sources of metalized defects
Hawkeye for optical density & pinhole detection

Types of defect:

- **Pinhole**
- **Scratch**
- **Macro-hole**
- **Tram-line**
- **Splashes / Starry Night**
- **Scarce metallization**

30mm each picture
**Background - Types and Sources of metalized defects**

Hawkeye for optical density & pinhole detection

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**Types of defect:**

<table>
<thead>
<tr>
<th>Defect</th>
<th>Description</th>
<th>Possible Causes</th>
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</table>
| **Pin-Holes** | 60 - 80 microns                   | - Dust/Debris on Substrate  
- Spitting of Al from evaporators. |
| **Tramlines** |                                   | - Heat wrinkle on web during metallization                                     |
Background - Types and Sources of metalized defects
Hawkeye for optical density & pinhole detection

Types of defect:

**Starry night**
Possible causes
- Dust on Substrate
- Spitting of Al from evaporators.
- Slippage at winder
- Blooming of migratory slip additives in polymer

**Micro and nano-defects**
Possible causes
- Interfacial roughness from anti-block additive
- Crystallization crack
- Small dust/Debris particles
Background - Types and Sources of metalized defects
Hawkeye for optical density & pinhole detection

Types of defect:

**Scarce Metallization**

Possible causes
- Poor surface treatment
- Poor cross web coating uniformity

**Scratch**

Possible causes
- Spitting from Al evaporators
- Debris on rollers
- Winding speed mismatches
Background - Why can a combined OD & PH in-line monitoring system help?

> Integration
- Reduced Cost
- Simple

> In-line
- Continuous monitoring
- Checks throughout full reel length
- Immediate feedback
Background - Current types of inspection system
Hawkeye for optical density & pinhole detection

> Off-Line sampled visual inspection
  > Time consuming
  > Subjective

> In-line inspection system outside the vacuum chamber.
  > Affected by outside influences, light cleanliness
  > Reduced accuracy
  > Needs separate OD measurement

> In-line inspection system inside the vacuum process.
  > Monitor close to web – better accuracy
  > Combined monitor and OD device
> Barrier performance (Oxygen & Water) is related to thickness of Al in a stable manner independent of ageing, whereas the OD is strongly affected by oxidation/ageing => ideal place to measure the Al thickness by optical means is under vacuum in the metalizer while no artefact is induced by partial oxidation of the coating.
The proposed solution for OD and PH monitoring
Main attributes

> An OD beam measuring up to 4.5 OD.
  > Pitch of 25mm to meet AIMCAL specification requirements.

> A defect beam that:
  > Detects, counts and categorizes pinholes from 0.1mm
  > Detects scratches as well as unmetalized areas
  > Gives full web coverage

> The design:
  > Combine OD measurement and PH detection in one device = UNIQUE !
  > Is modular and easy to calibrate
  > Has a simple user interface
  > Stand Alone or integrated
  > Fully Adjustable
  > Provides data logging and reporting (in development).
  > Durable and robust design.
The proposed solution for OD and PH monitoring

Probes assembly

Rhombus shaped probe gives sensor overlap for 100% web width detection of pin holes

Same box used for transmitters and receivers
The proposed solution for OD and PH monitoring

Performances

Others:

> Easy cleaning

> Easy to add / remove module

> Vacuum compatible

> Minimum size :
  section < 140 x 200 mm

> Thermal stability over whole range,
  ambient temperature <= 45°C

> Stable : 1 month without calibration.

Half a turn releases the probe.
Simple and quick probe replacement.
The proposed solution for OD and PH monitoring
Performances

> Four 25mm wide light beams per probe.
> No gaps between light beams in probes.
> No gaps between beams in adjacent probes (half of probe 2 is shown).
> Hence 100% coverage.
> Optical arrangement gives parallel light path so it’s insensitive to gap variation.
> 1mm vertical tolerance between transmitter and receiver mounting.
The proposed solution for OD and PH monitoring Performances

- This slide indicates the light transmission (converted to voltage) over a given distance.
- The Peaks indicate a Pin Hole / Defect,
The proposed solution for OD and PH monitoring

Performances

- **Counts and classifies** holes in 3 sizes
  - Ranges: $<0.2 \text{ mm}$; $0.2 \text{ mm}-0.8 \text{ mm}$; $>0.8 \text{ mm}$
  - Range classification can be changed through software
  - Minimum size of detectable holes between $0.1 \text{ mm}$ and $0.2 \text{ mm}$
  - Counts up to 255 max holes for each category at each sensor ($\leq 8\text{ bits}$), sampling rate $500\text{ ms}$ or larger

- **Scratch detection**: Hole size longer than $2 \text{ mm}$ will be classified as a scratch (4th category)

- **Film on which the detection applies**: $\text{OD} \geq 1.8$

- **Production speed**: $1000 \text{ m/min}$. 
The proposed solution for OD and PH monitoring
Field trial performance: on 15 year old metalizer

Pinhole results:

LARGE PINHOLE CHART

Production start
Pinhole results: Test made

Production start

SMALL PINHOLES CHART
The proposed solution for OD and PH monitoring
How to close the loop on the metalizer?

> Analysing inline **density & size distribution of small pinholes** - range of 0.1mm to 0.2mm - opens the way to regulate machine parameters to keep this histogram in a safe region enabling the statistical cancellation of large troublesome pinholes over a roll.

Principle of extrapolation of the density of unwanted rare events of large pinhole based on density analysis of small pinholes.
The fast analysis of the system opens the possibility to monitor OD only on dedicated areas not only in transverse direction but also along the machine direction, this enables for example to regulate OD deposition even aluminum is partially removed on certain area along the web (machine XXX of GEN). Accordingly, the PH check could also be implemented in such applications on the defined and metalized areas.

The high sensitivity of the system allows the usage of PH monitoring to be used for laminator industry and plain foil manufacturers.

Film manufacturers could also be interested in the high stability and accuracy of the system to monitor the transmission of the line across the full web width detecting online opaque or diffusing events on the web.

On a slitter it can be used to monitor the final quality and stop the slitting process to extract non-quality.
Conclusions

> This unique device definitively opens the way for an increase in manufacturing quality.

> It could also help to establish new standards for quality control.

> The product demonstrates in deeper detail, the relationship between pinhole density and sizes with process parameters.

> This may also help to establish relationship in the pin-hole sizes and the loss of permeation of coated films.
Thank you for your attention