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SURFACEVISION

INTERNATIONAL WROUGHT COPPER COUNCIL

Surface Inspection and Monitoring Systems for the Copper Industry

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AMETEK®
SURFACE VISION

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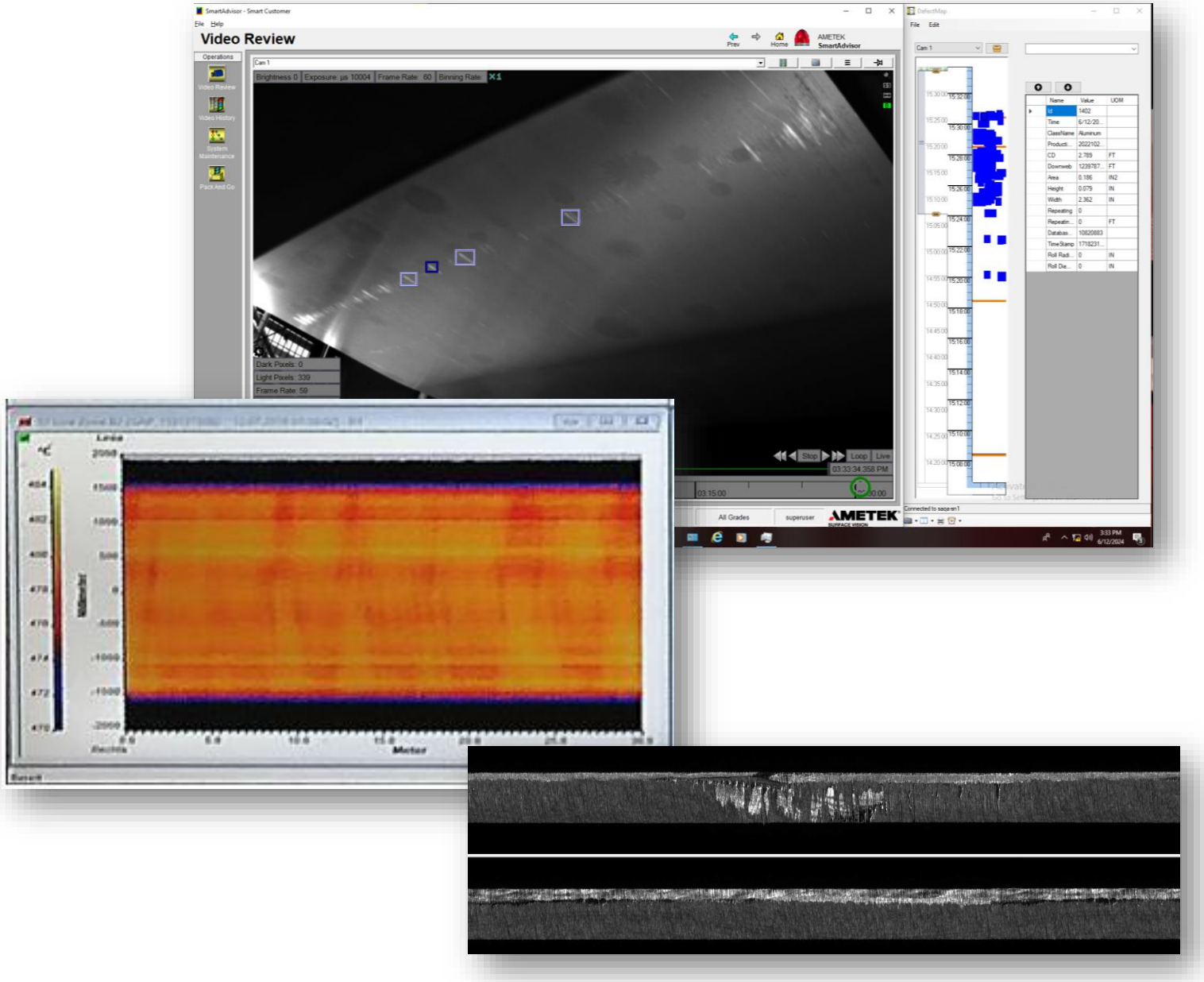
IWCC Legal Disclaimer

- The purpose of this presentation is to guide programs benefiting the copper industry and to provide attendees with information to make independent business decisions.

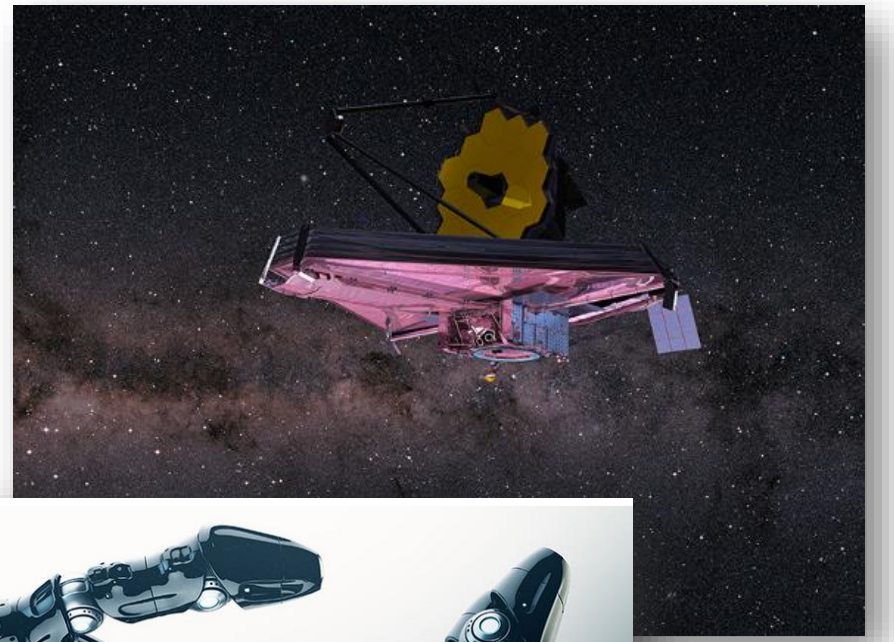
Agenda

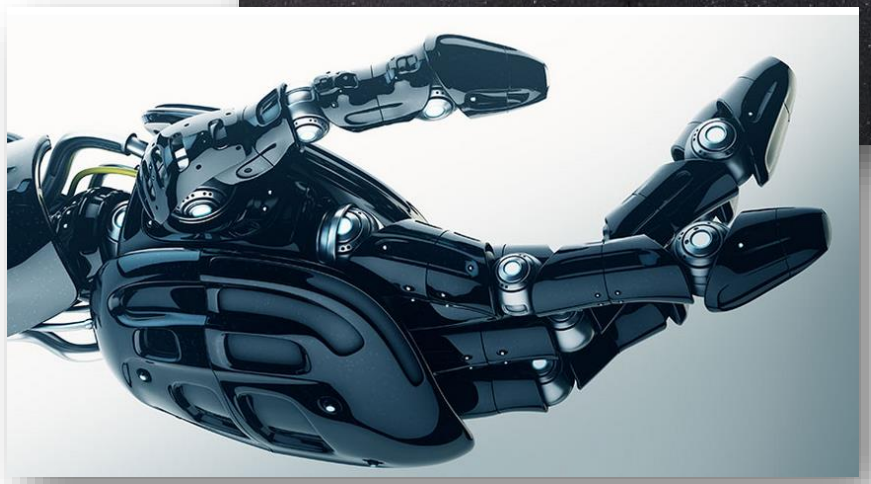
- AMETEK Overview
- Process Monitoring
  - Streaming Video
  - Process Video
  - Temperature (IR) Sensors
- Edge Quality Monitoring
- Surface Inspection



AMETEK

- Global manufacturer of high-tech industrial products
- Quoted on the NYSE (AME) since 1930, headquartered in Berwyn, PA
- Annual sales of $6.6 billion in 2023.
- Serve a diverse set of niche markets and applications
- Distributed operating structure with ~18,500 colleagues
- 150 operating locations in 30 countries





Solving complex challenges to make the world a better place. It's what we do.

Applications

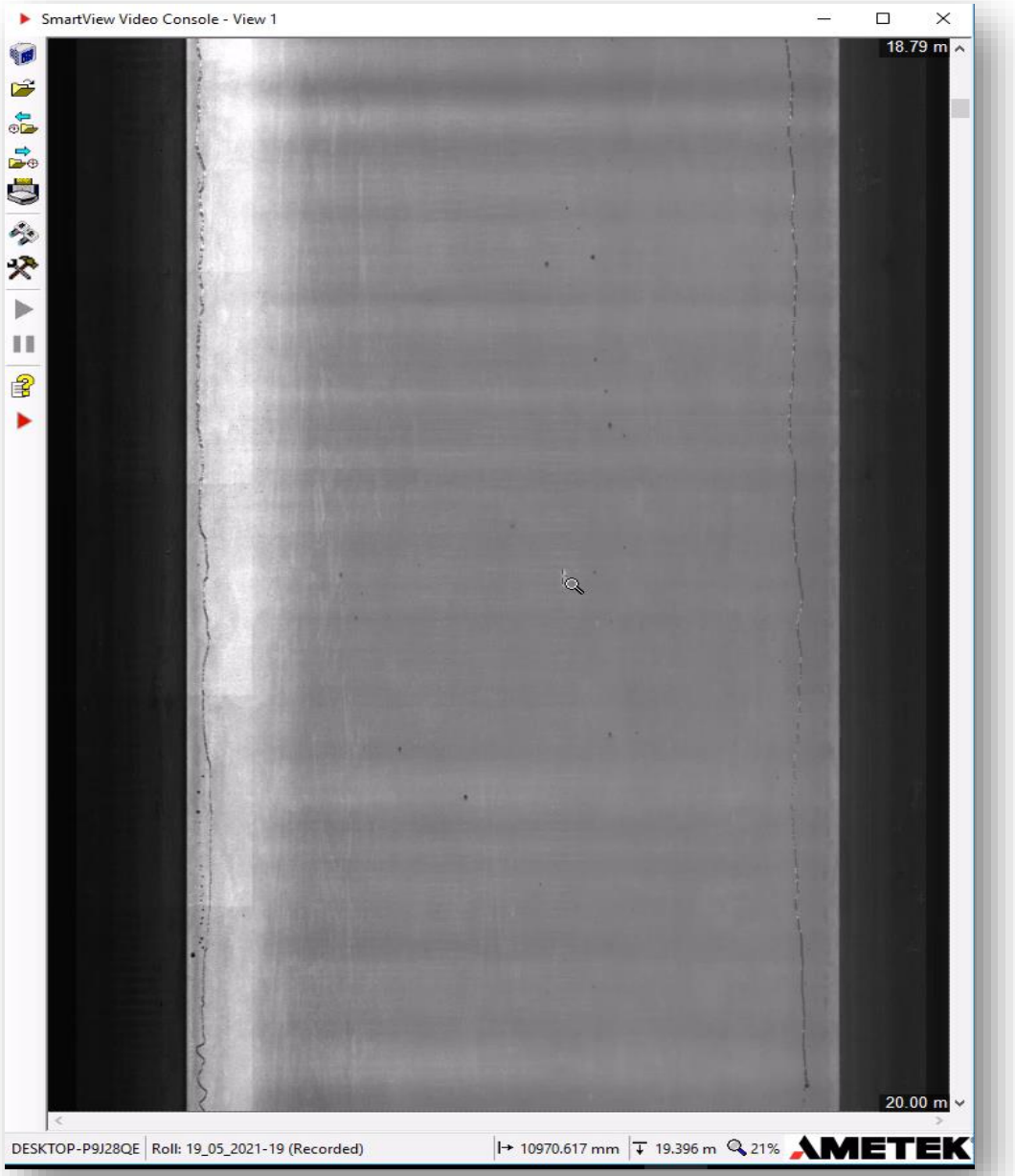
Covering all steps of flat sheet production:

- Milling
- Pickling line
- Cold rolling mill
- Annealing line
- Stretch bend leveler line
- Coating line
- Foil treatment line
- Inspection line
- Slitter
- Automotive Lithium-Ion batteries
  (anodes material based on copper foil)

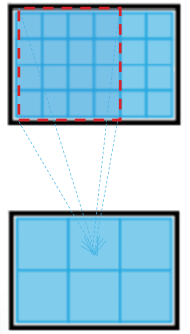
Over 3,000 SmartView installations with more than 1,000 in Metals

Streaming Video

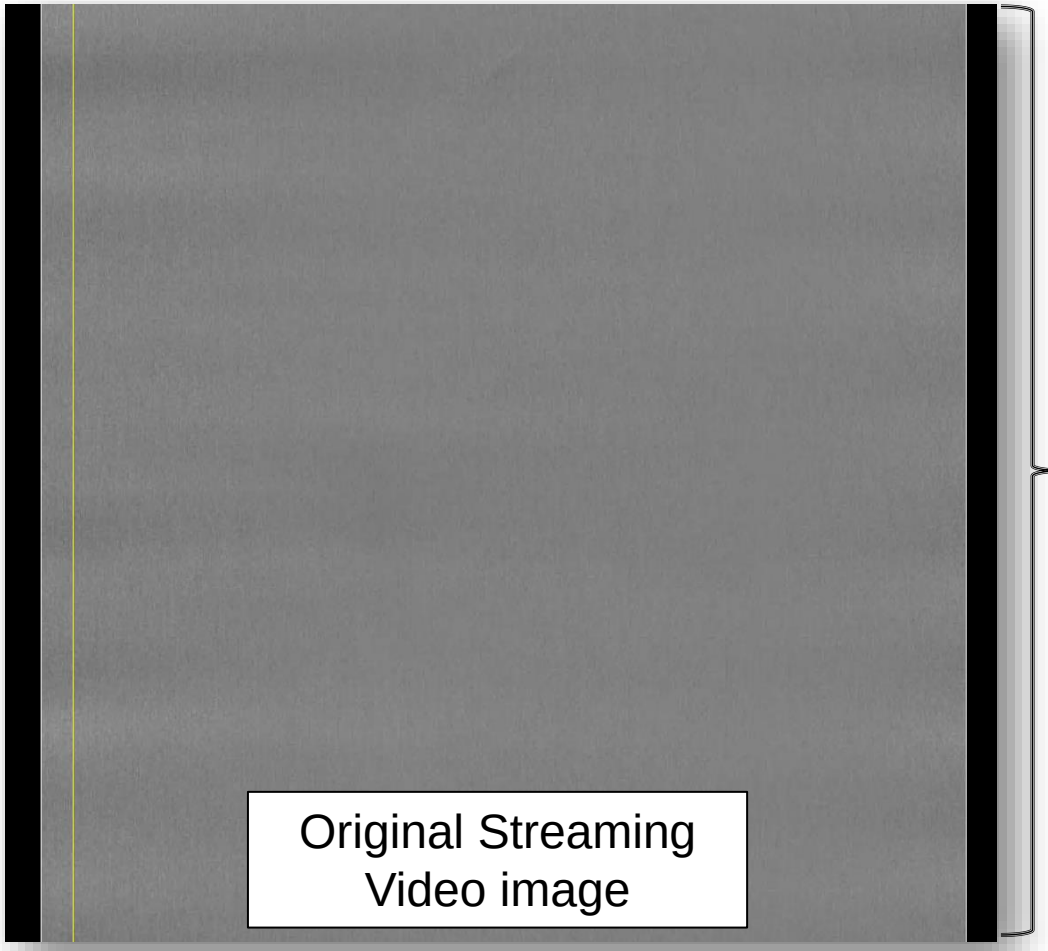
- ✓ Same resolution as SmartView inspection
- ✓ Lossless image compression
- ✓ Days of production videos. Each camera can have up to 40TB at the camera level!
- ✓ Ability to lock coils
- ✓ **Virtual coil rerun**
- ✓ **Golden coil for detection and classification improvements**
- ✓ 60 fps update rate, smooth scrolling, “catch-up” mode after live mode pause, and more!
- ✓ Many live mode settings: pause at start of inspection, start scrolling automatically, etc.



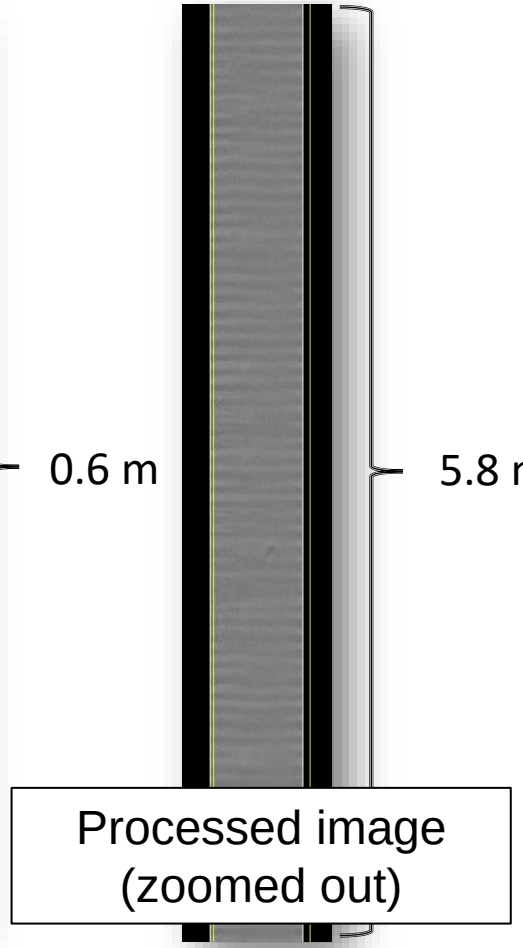
VirtualView Inspection + Low Resolution Filter



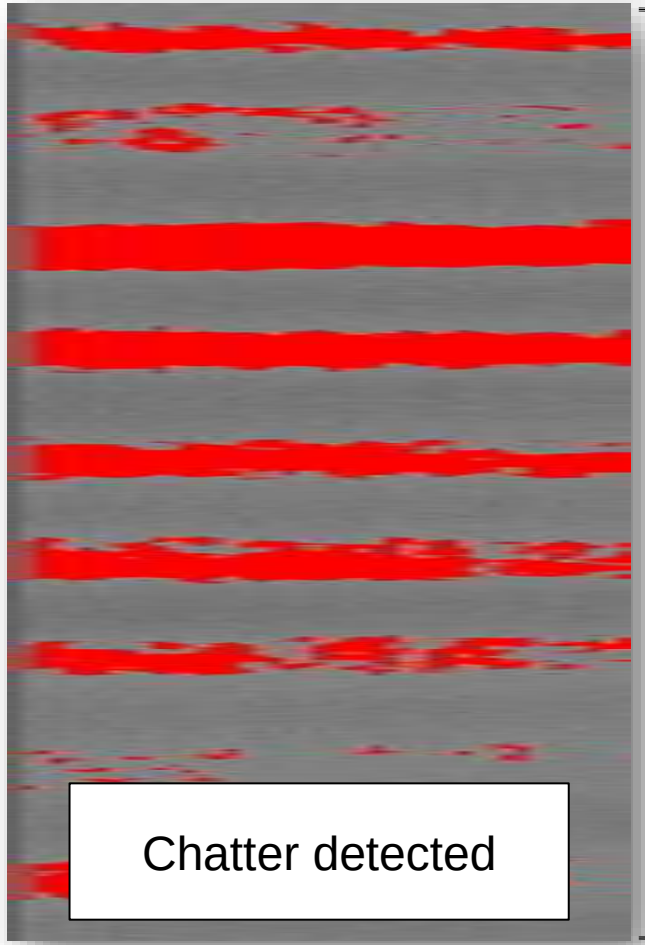
- Rolling mill chatter creates large, low contrast defects



0.6 m



5.8 m



1.7 m

SmartAdvisor 6.0

Latest Generation – based on 30+ years of experience

Monitoring Solutions

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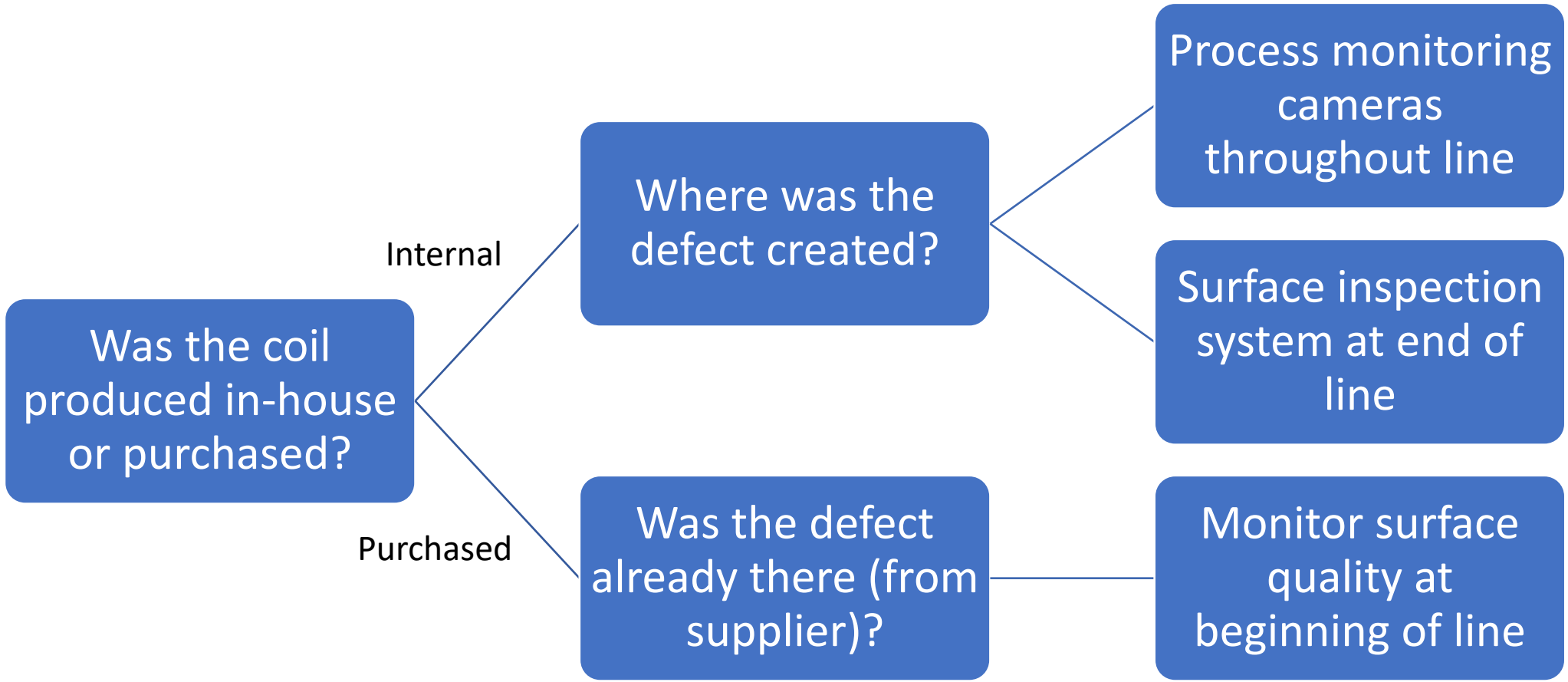
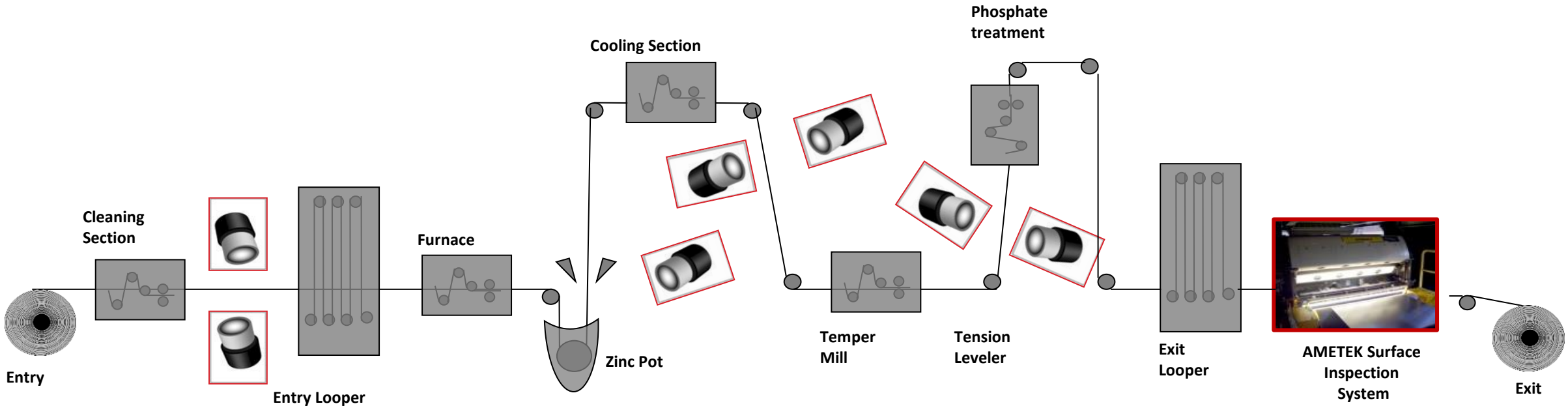
The system detects a defect, now what?



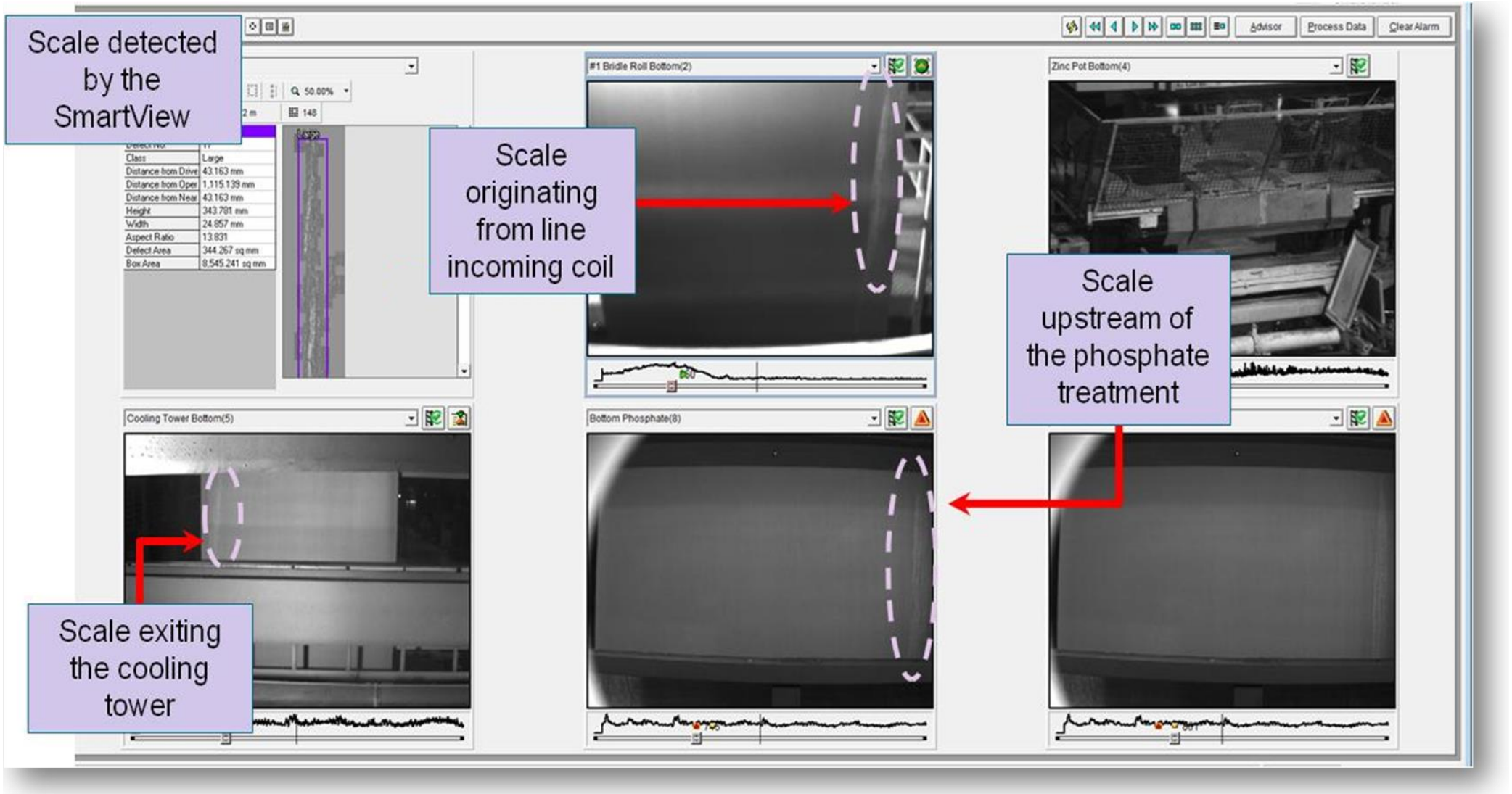
Integrating Surface Inspection + Process Monitoring



- Monitor **different locations** or **areas** of your process
- Synchronize SmartView and SmartAdvisor cameras for **root cause analysis**

SMART ADVISOR®

Integrating Surface Inspection + Process Monitoring



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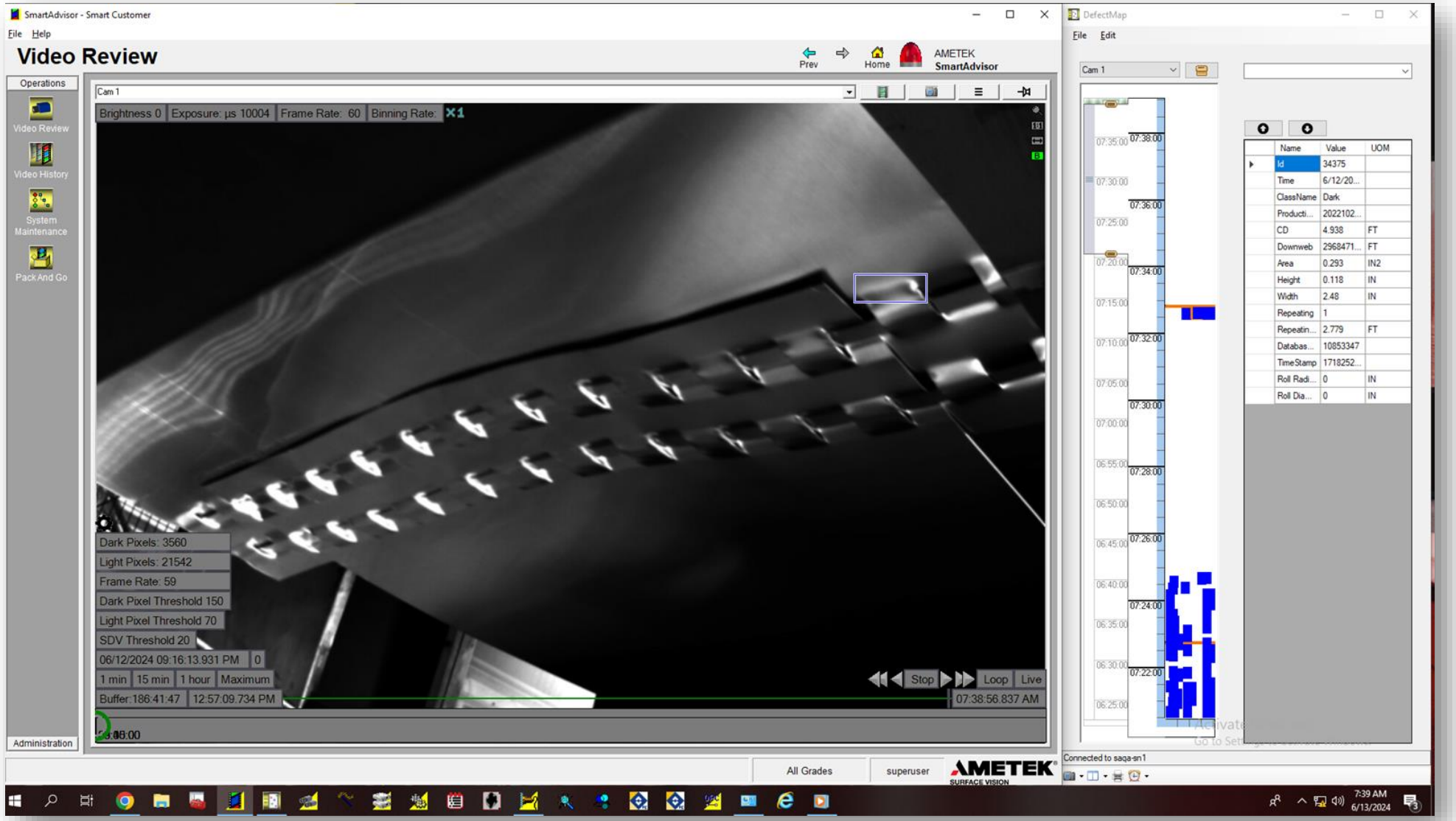
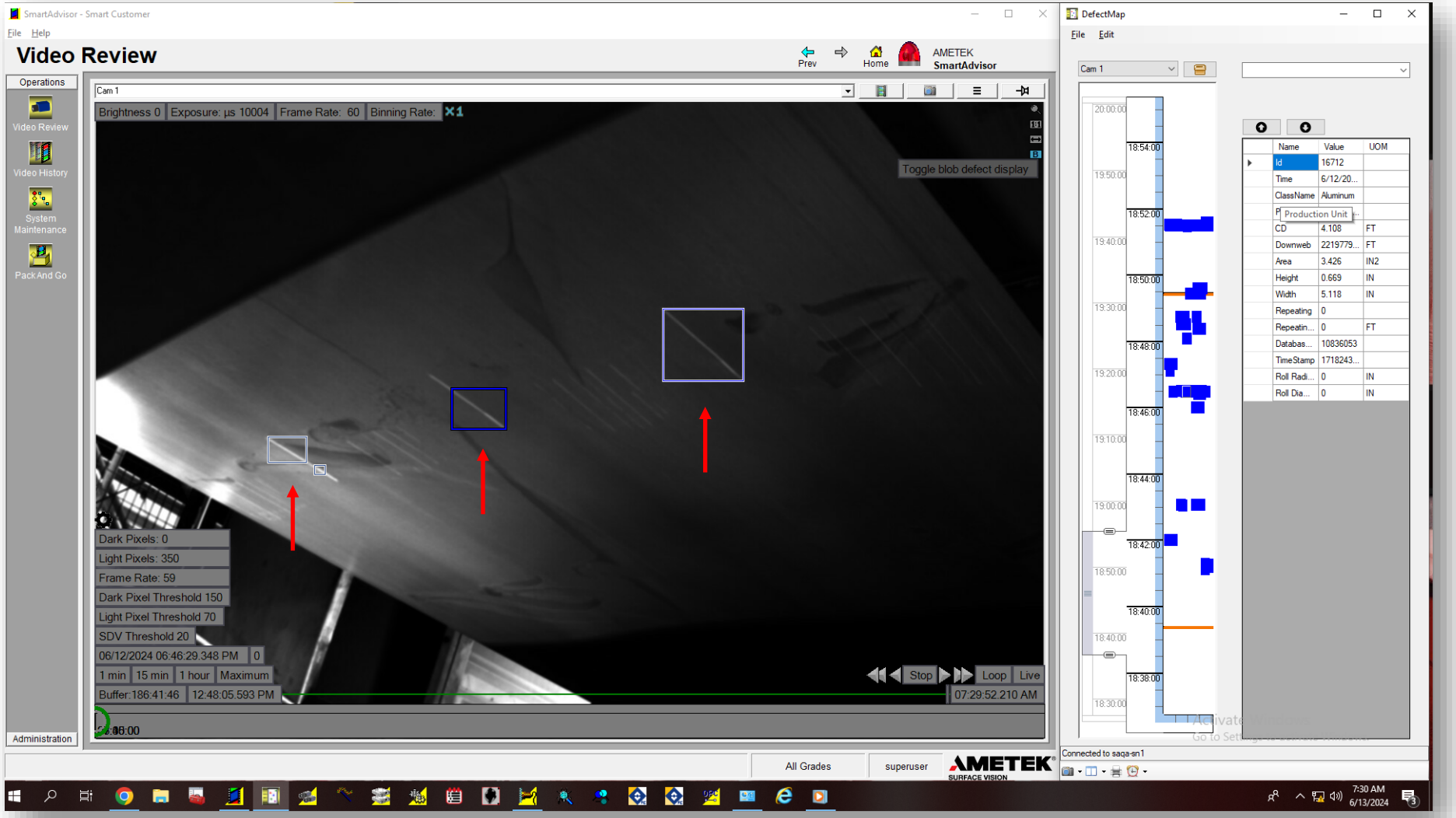
Process Monitoring – Heat Treat Furnace Exit (Stitch)



Process Monitoring – Heat Treat Furnace Exit (Scratch)



Scratches detected

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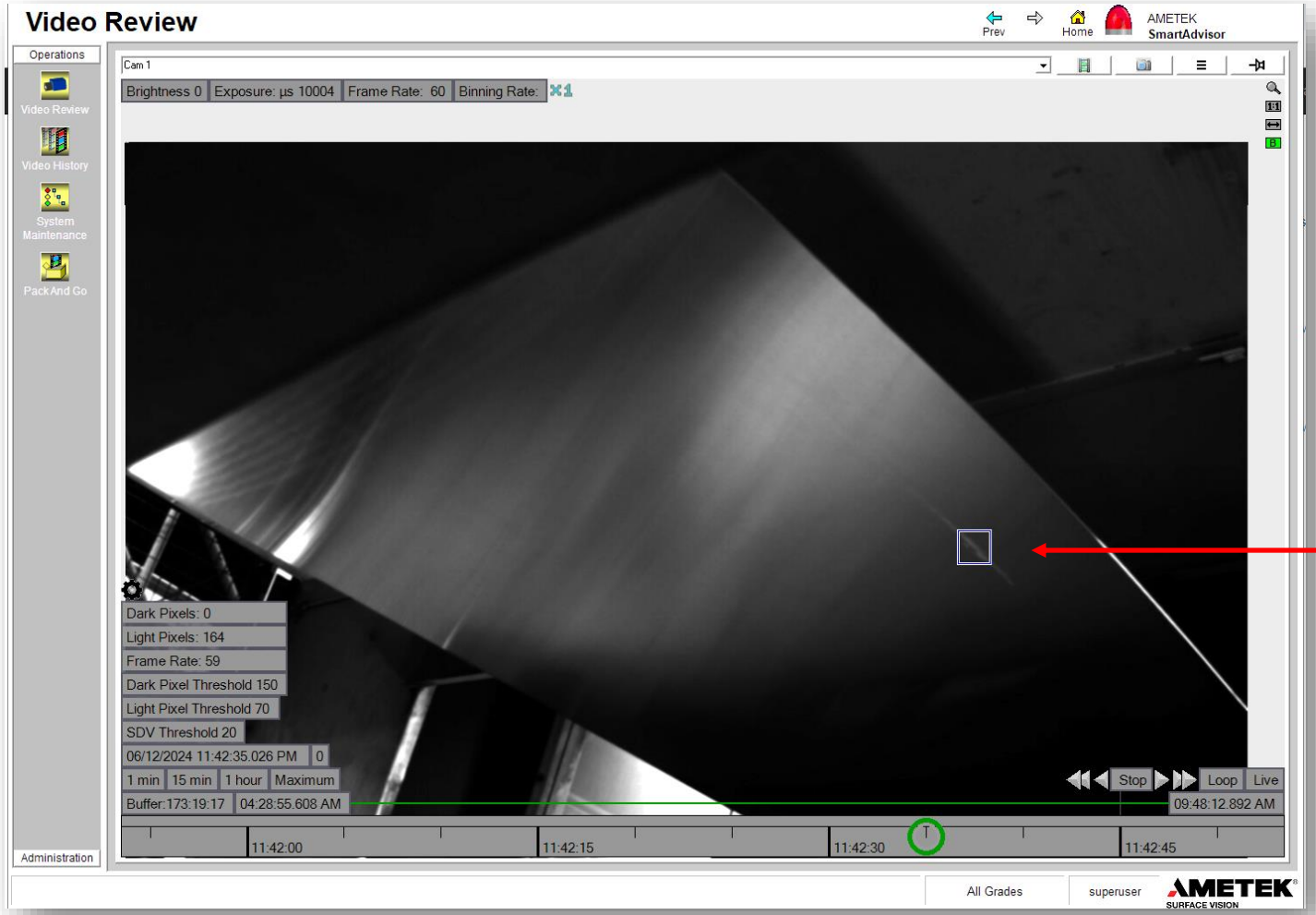
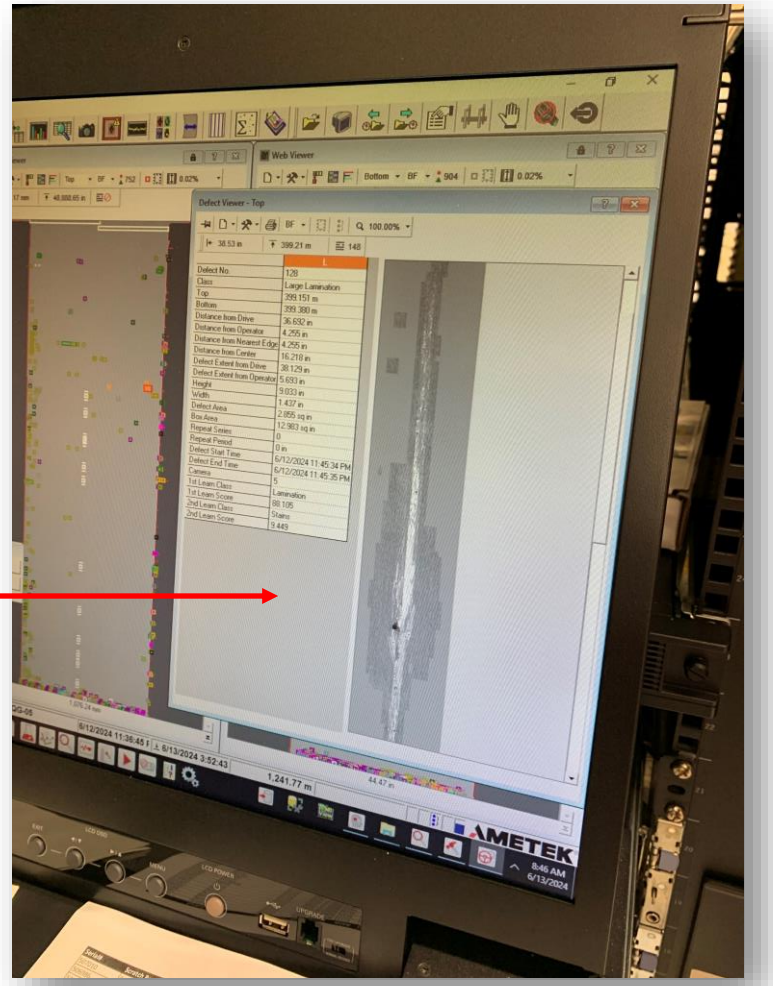
Process Monitoring – Synchronized w/ Surface Inspection



Process Monitoring – SmartAdvisor System – At Exit of Heat Treat Furnace



Surface Inspection – SmartView System – At End of Heat Treat Line

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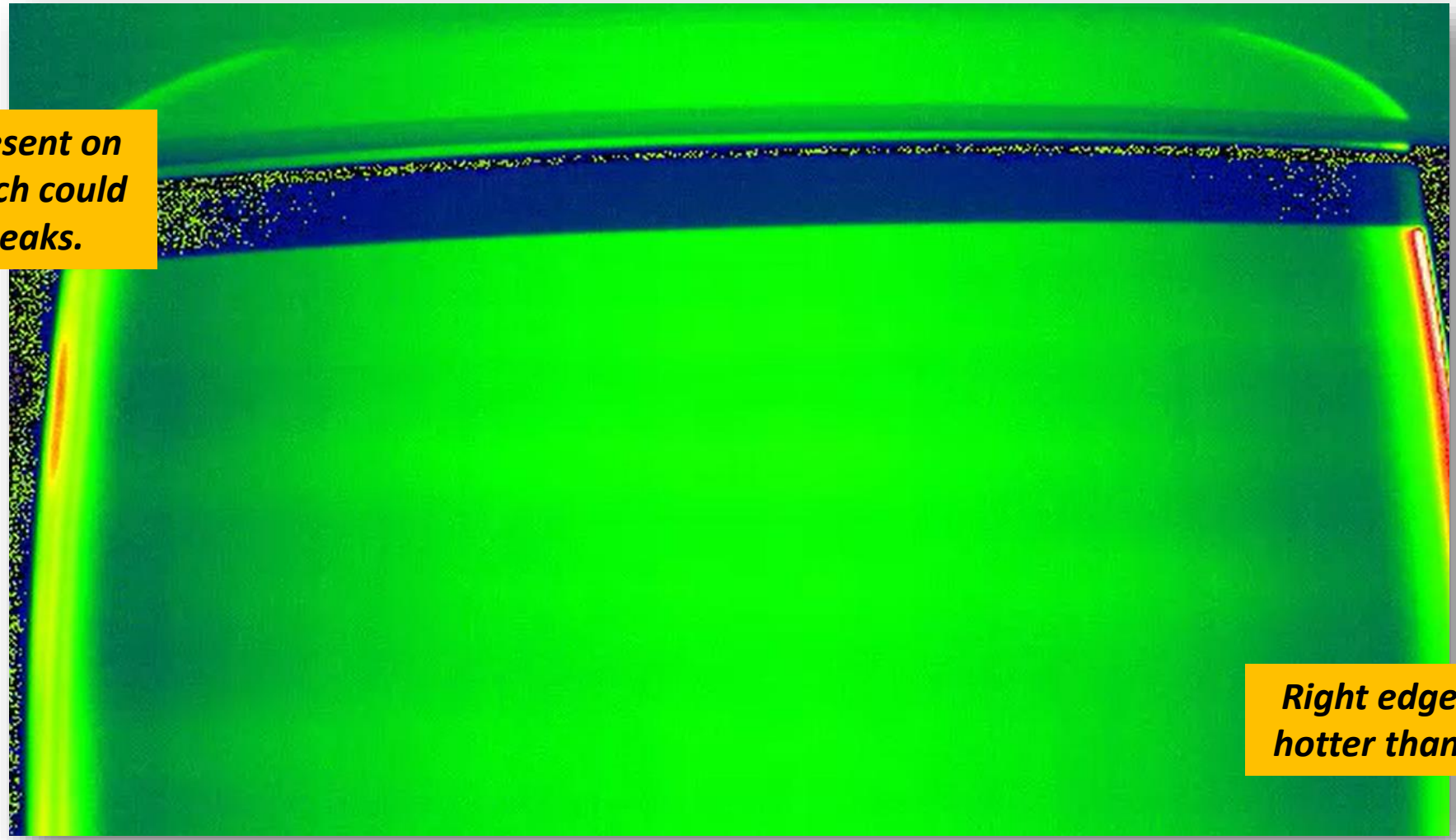
Process Monitoring – Temperature (IR Camera)

Hot spots are present on the left edge which could lead to strip breaks.



Right edge of the strip is hotter than the left edge.

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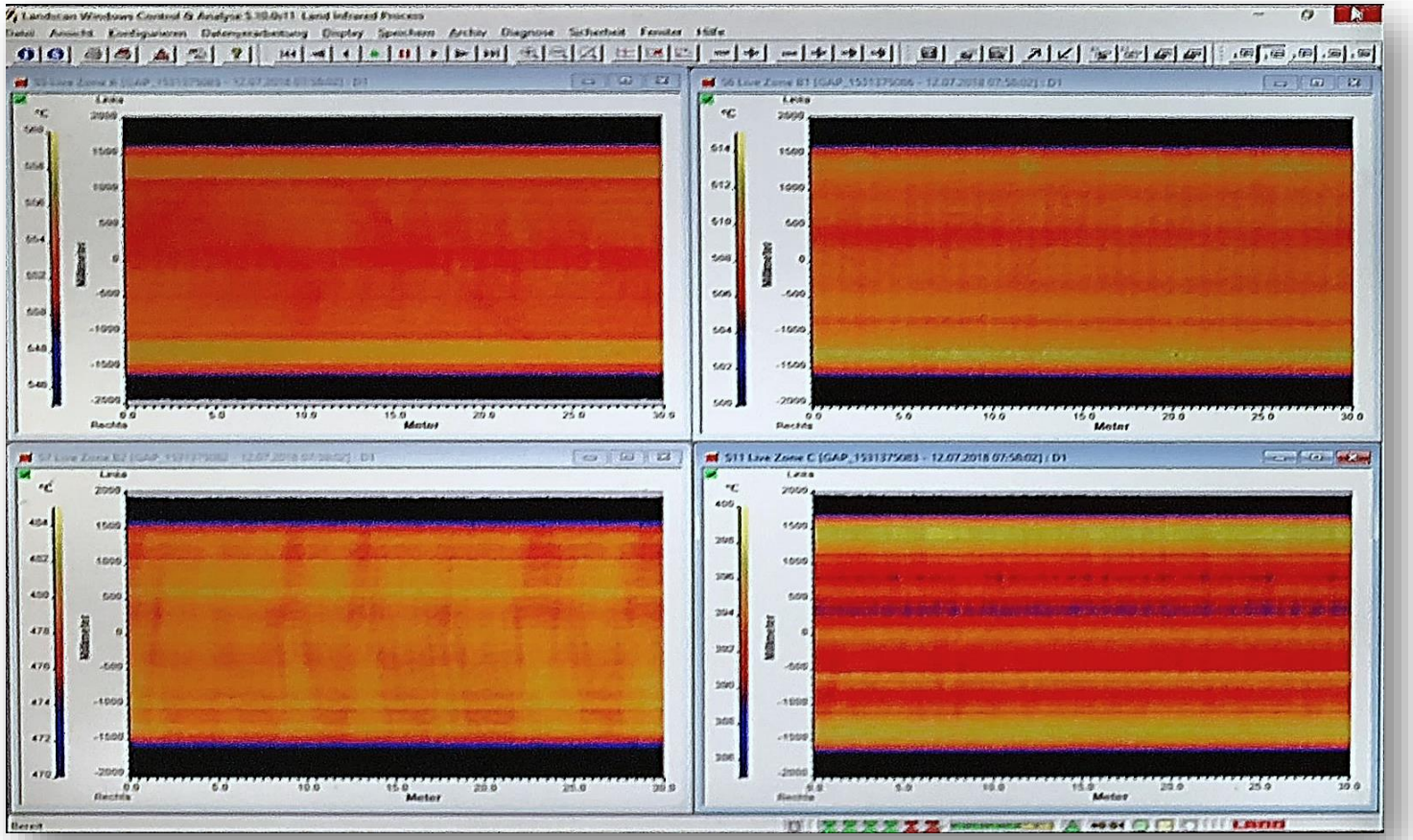
Process Monitoring – Temperature (Casting)

Application

Copper Slabs/Bars Casting
Temperature measurement in bar and slab processing and production

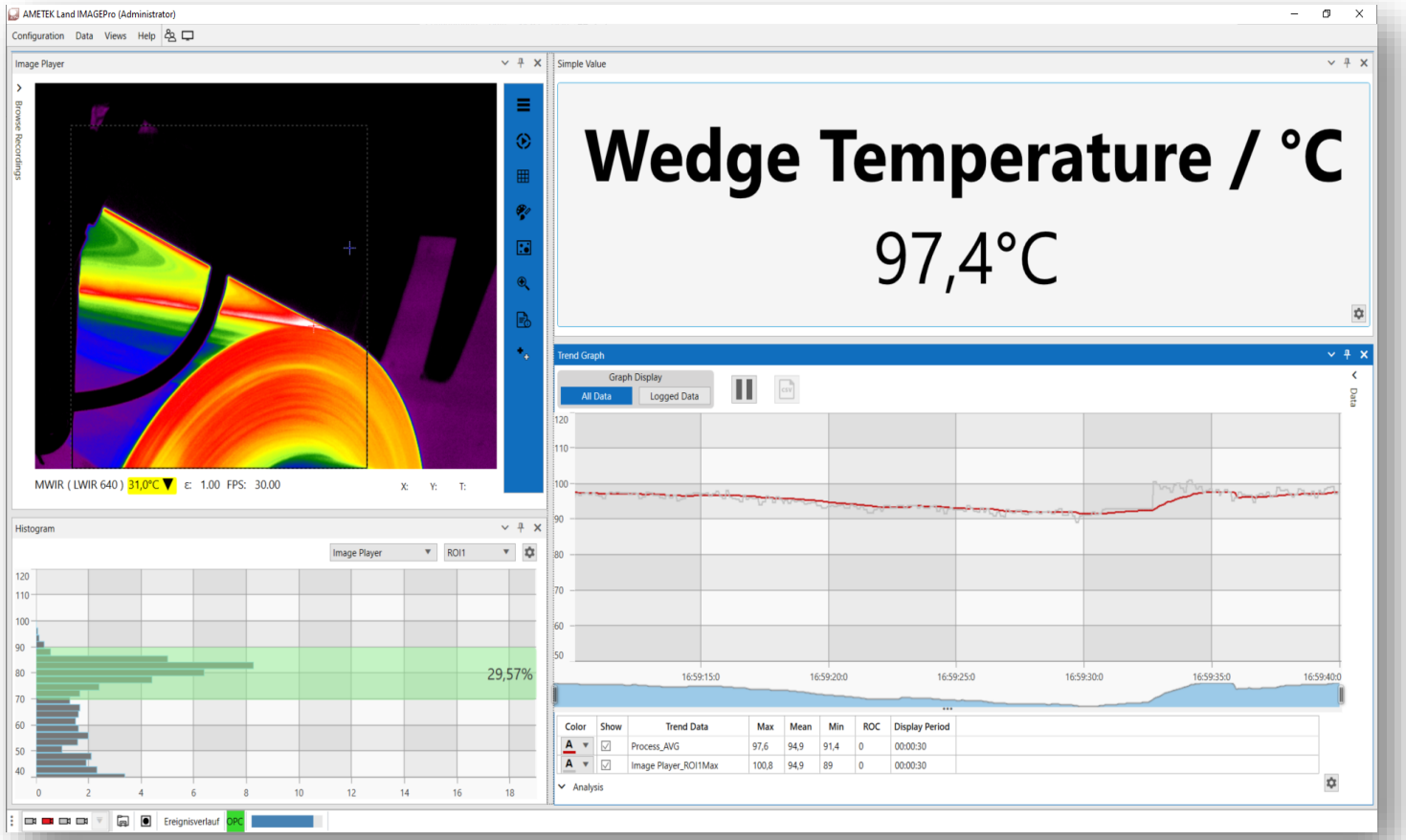


Profile temperature measurement in copper casting and hot rolling processes using **line scanners** to provide a full thermal map of the product and control the process.

Process Monitoring – Temperature (Cold Rolling)

Application

Copper Cold Rolling and Coiling
Temperature measurement in cold rolling processes and for copper strip and foils



Using the wedge effect, thermal imagers (scanners or pyrometers) are used to measure the strip temperature continuously to monitor and control the process.

SmartEdge

Latest Generation – based on 30+ years of experience

Monitoring Solutions

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SmartEdge – Knife Edge Monitoring

Avoid Scrap

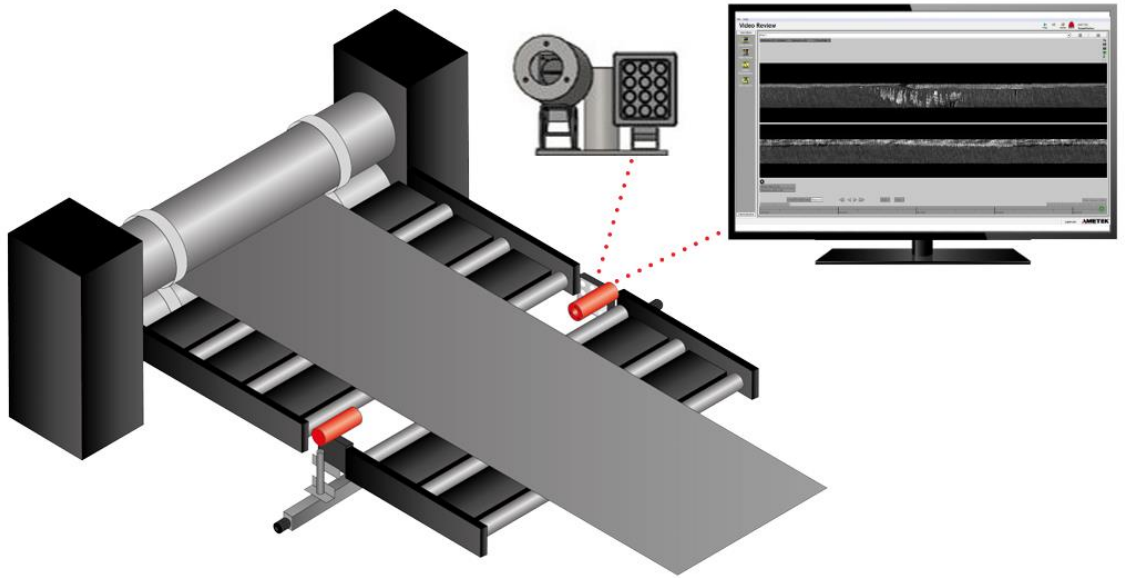
- Detect the onset of edge burr now, before bad product is produced
- SmartEdge Monitoring show knife wear is approaching time for maintenance

Reduce Knife Wear

- SmartEdge Monitoring provides real-time feedback for knife adjustment while running, so knives stay in proper alignment for the longest possible life

Meet Customer Quality and Tonnage

- SmartEdge Monitoring helps keep your line running smoothly with less downtime for improved yield
- Edge quality is always in view



SMARTEDGE®

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SmartEdge – Knife Edge Monitoring

Auto-Calibration

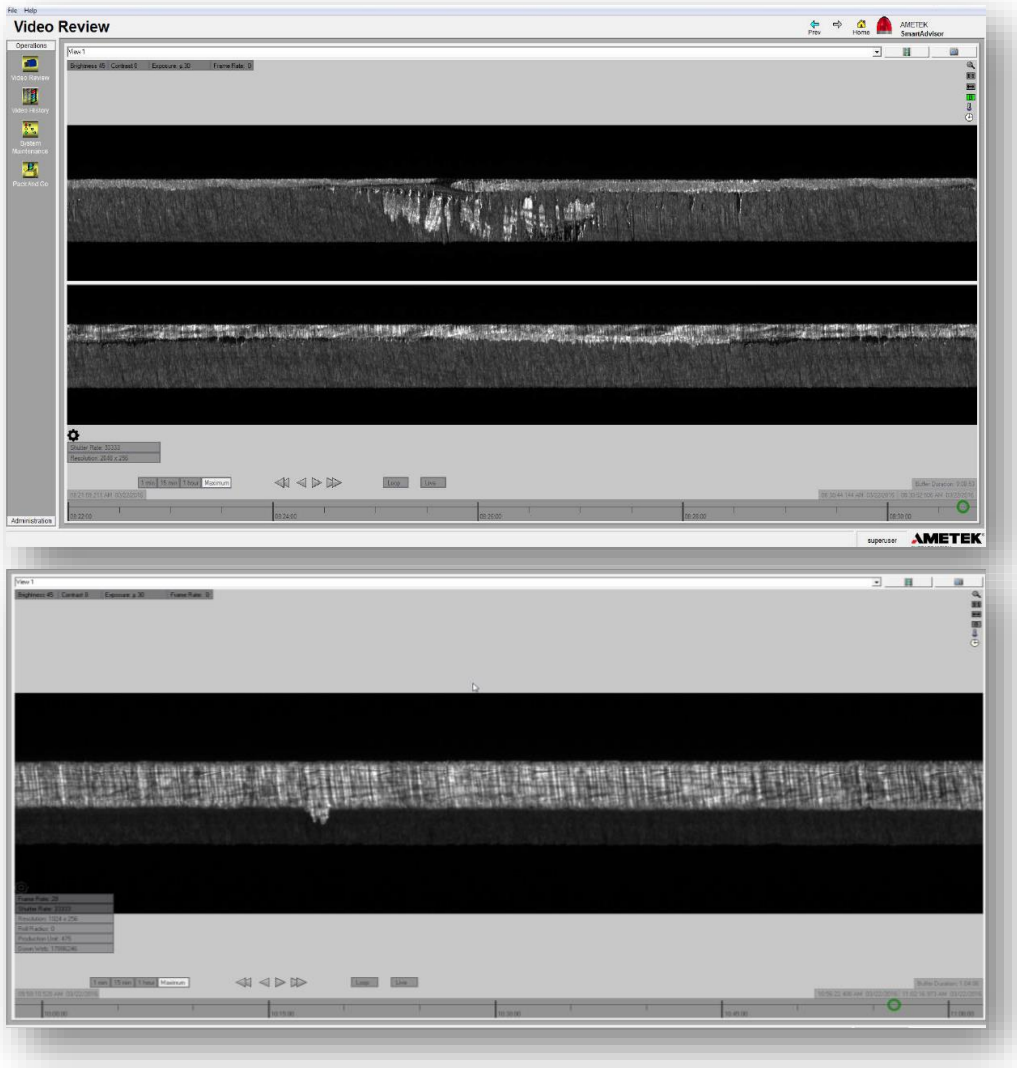
- Thickness changes are detected and presented onscreen at the best magnification of the edge.

100% Video capture and storage

- SmartEdge captures the entire length of the trimmed edge
- Events can be found and analyzed for root cause.

Stabilized Video

- Large-sensor linescan cameras make SmartEdge immune to material bounce even at high magnification.
- Stabilized video on-screen helps the operator see subtle defects and even shows knife eccentricities in the cut.



SmartView 9.0

Latest Generation – based on 30+ years of experience

Surface Inspection

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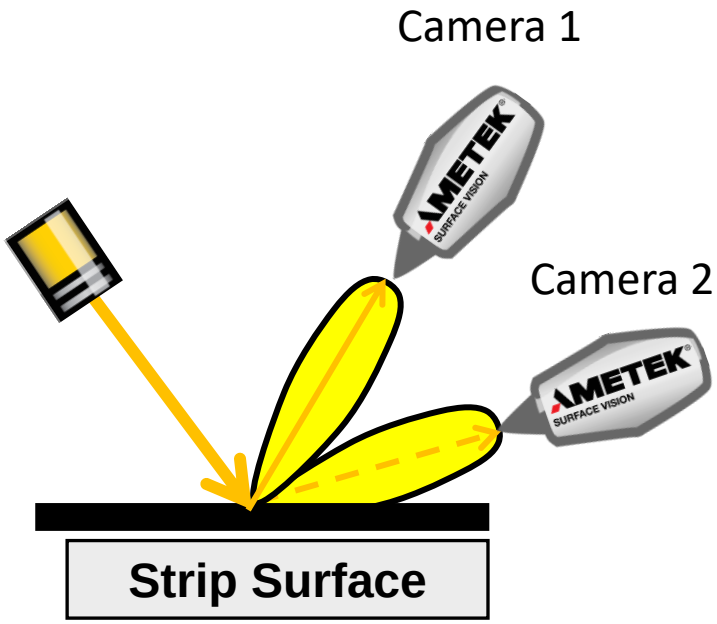
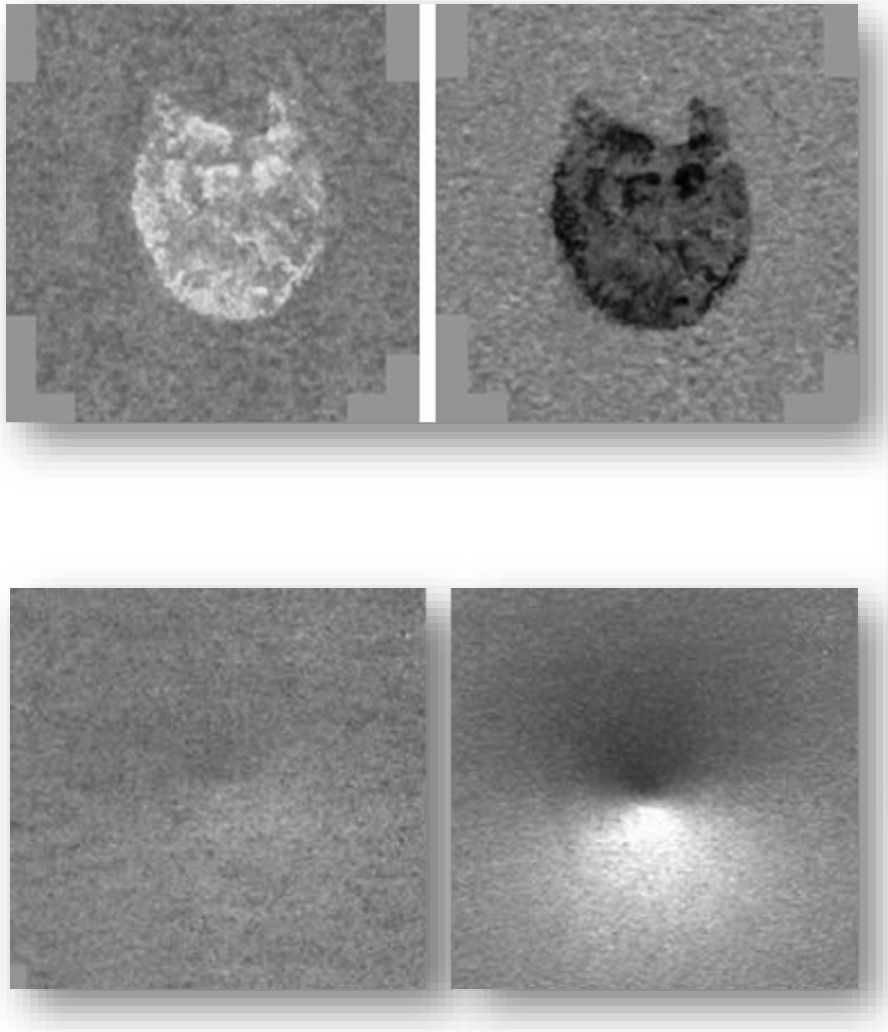
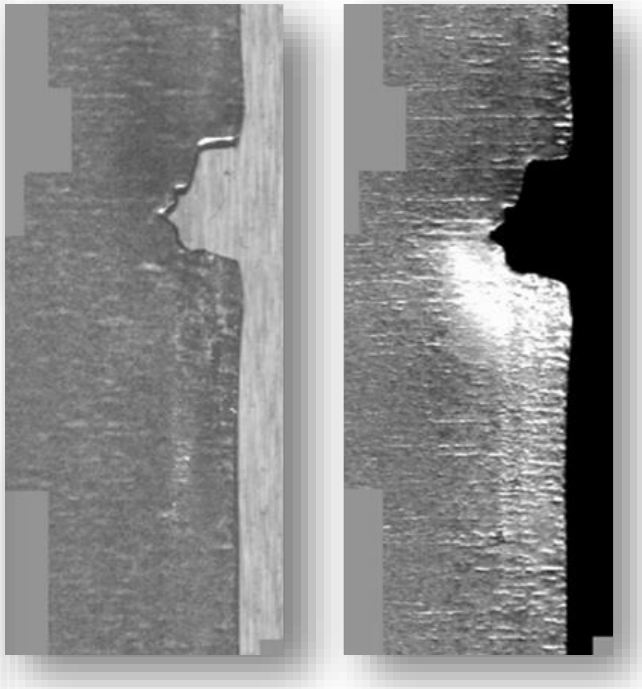
Surface Inspection Principles

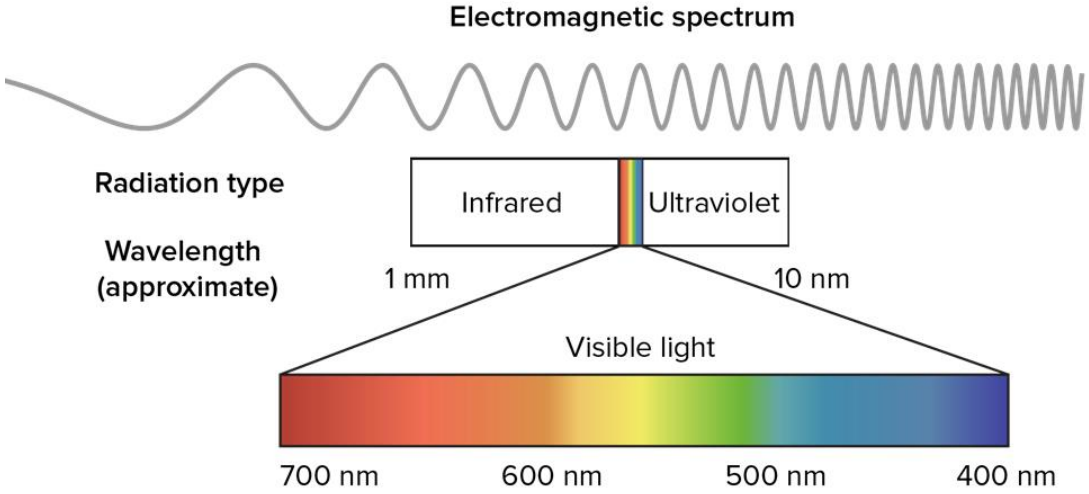






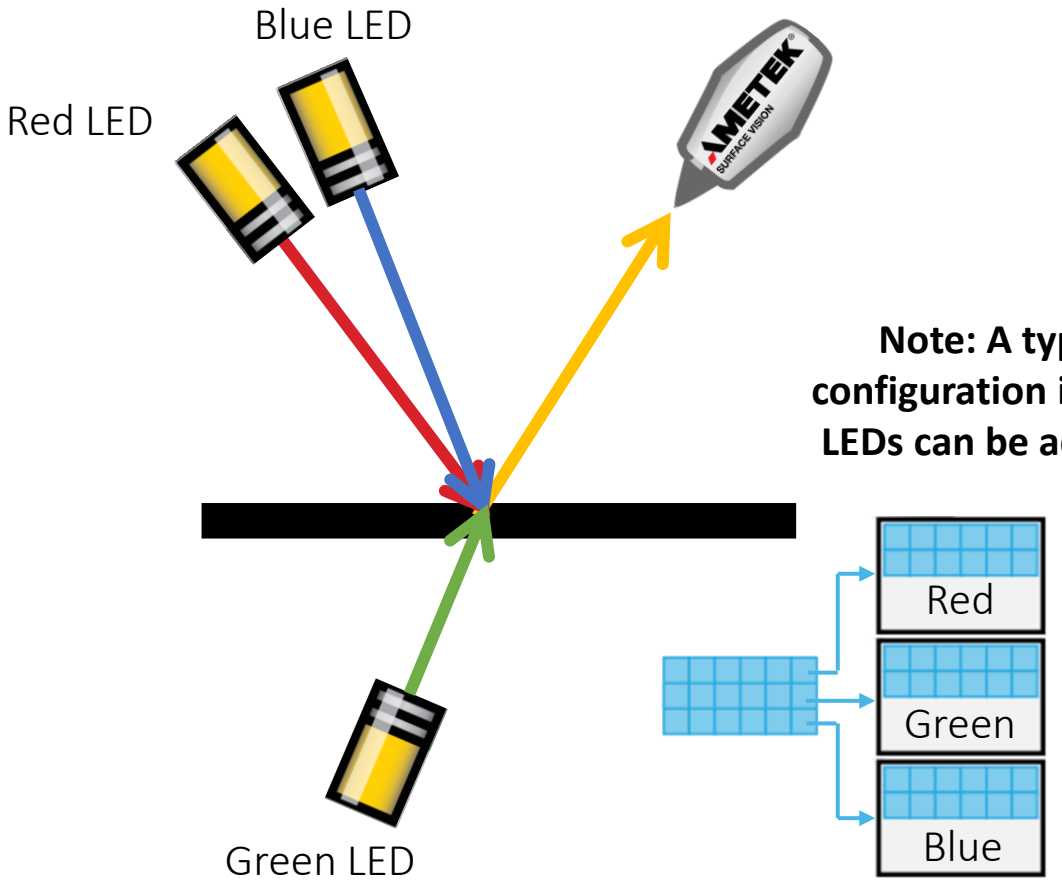
Evolution of Surface Inspection

- Camera sensors
  - CCD → CMOS
  - High Sensitivity
  - High Speed
  - High Resolution
- Illumination
  - High power LED
  - Collimated or diffused
  - **Full light spectrum (from IR to UV)**
- Software
  - New, powerful computers are suited for the computing demands of machine-learning/AI software
  - A single computer can process multiple camera signals



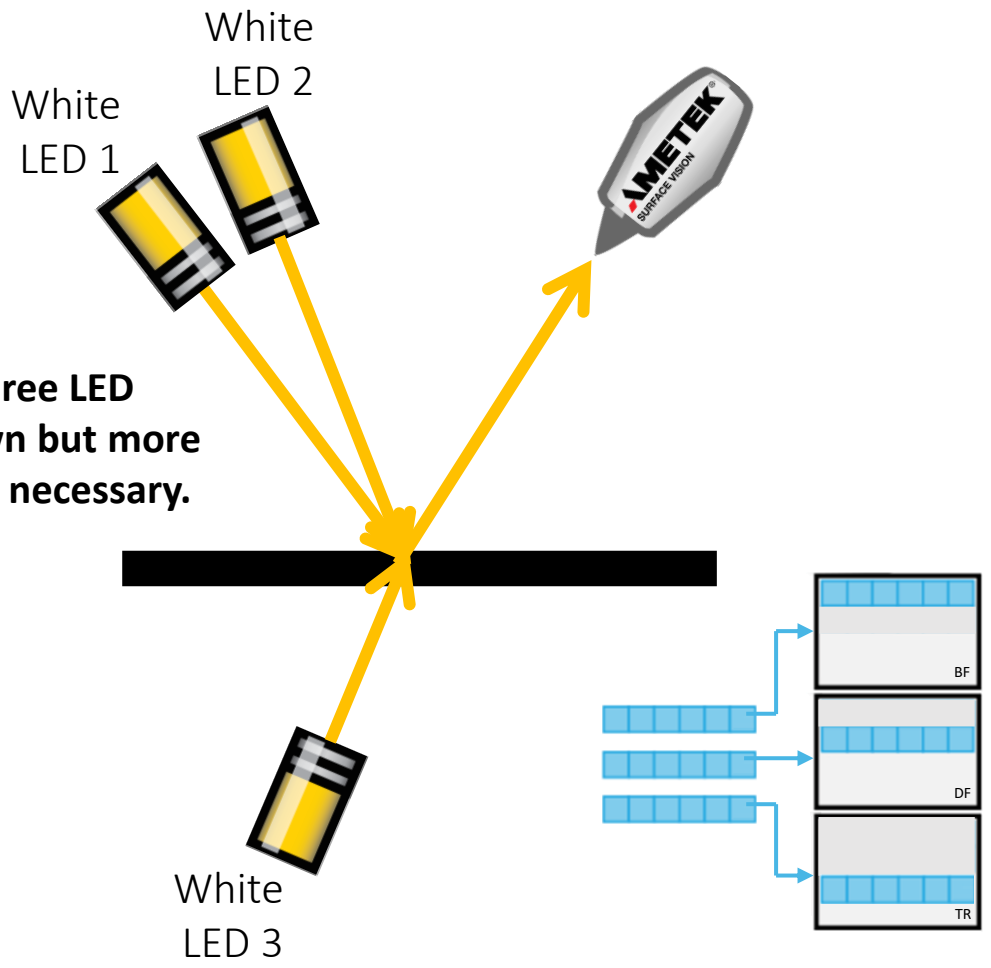
Evolution of Surface Inspection – Multi-Channel Options

Continuous Color Inspection



Note: A typical three LED configuration is shown but more LEDs can be added if necessary.

Time Multiplexing



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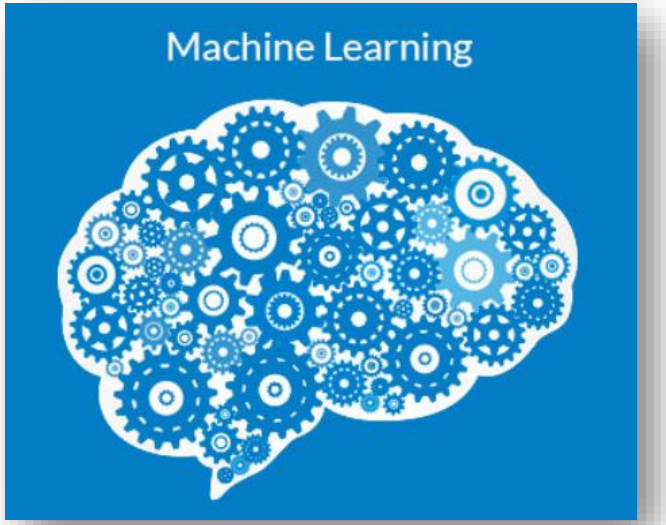
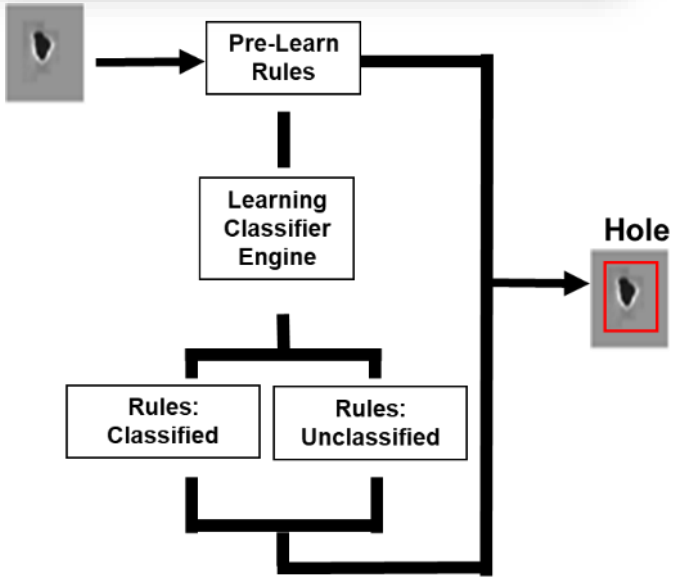
SmartLearn – Machine Learning (AI)

- SmartLearn uses machine leaning (AI) to enable it to learn without being directly programmed.
- SmartLearn uses a machine learning algorithm to learn how to recognize different defects.
- “Training” is simply done by collecting image samples and allowing it to adjust itself and improve.
- By utilizing Color Multiplexing and VirtualView, SmartLearn has multiple images of the same defect which improves classification accuracy.
- SmartLearn allows simple classification rules (ex. Repeaters) prior to machine learning algorithm and after making easy to adjust.
- The interface is designed for the end user with a simple and powerful interface.





Benefits of Color Multiplexing/VirtualView + SmartLearn

- Color Multiplexing provides **continuous** inspection for multiple camera/light angles to provide multiple images of the same defect.
- VirtualView provides **continuous** inspection and allows multiple classifiers and recipes to be used for a single physical camera.
- Powerful defect classification software (SmartLearn) increases classification accuracy when compared to rules-based classification.
- With optimized defect classification, identifying where defects are occurring is simplified and corrective actions can be taken quickly.
- By reducing the number of defects, production yield is maximized.

Thank You

Questions?

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