GPC # Life Beneath Pavers, Operating Furnaces for Years after Glass Breaches

Mohit Gohel
PaneraTech, Inc., United States

Extending Furnace Life Through Early Detection & Data-Driven Action

Radar detection spots refractory wear and glass penetration 2-3 years before temperature increases, enabling proactive cost-saving maintenance.

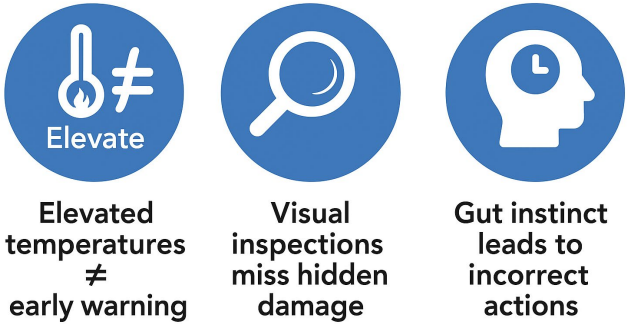
Polaris™ analytics outperform temperature readings, revealing true wear to optimize cooling, improve furnace operation and extend asset life.

Data-driven actions – precise cooling and timely repairs – extend furnace life by 5 to 6 years even after glass has penetrated to the bottom insulation.

Preview

Insights from 550+ furnace inspections and over 2 million refractory data points reveal: Traditional methods are not enough to predict refractory maintenance.

Unreliable as well as late Indicators for Refractory Maintenance Decisions



Glass Penetration Detection: Temperature Is a Late Indicator

Temperature disguised due to insulation layers

Relying on temperature = late-stage detection.

Radar detects issues 2–3 years earlier.

Early detection = lower costs + longer furnace life.

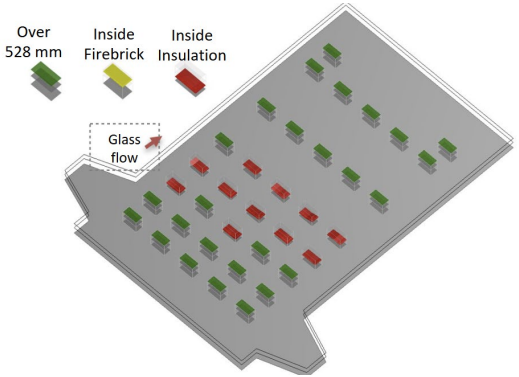
Surface Temperature Isn't Reliable

Why It Matters: Surface temperature increase after damage; radar detects risks early for proactive maintenance.

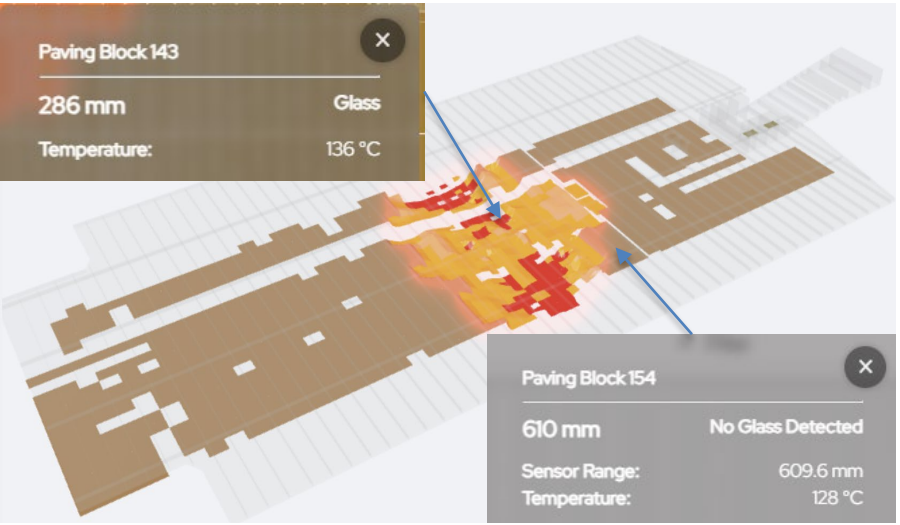
Customer Goal: Extend furnace life safely by catching risks early.

Challenge: A hot spot at the furnace bottom raised concerns about structural integrity and a possible glass leak.

PaneraTech Technology Insight: Radar finds bottom thinning months or even years before temperature increases.



Temperature is a late Indicator



Cold face Surface Temperature (Degree C)	Refractory Thickness (mm)
136	286
145	454
128	610

Radar detects refractory loss years before surface temperature shows any sign.

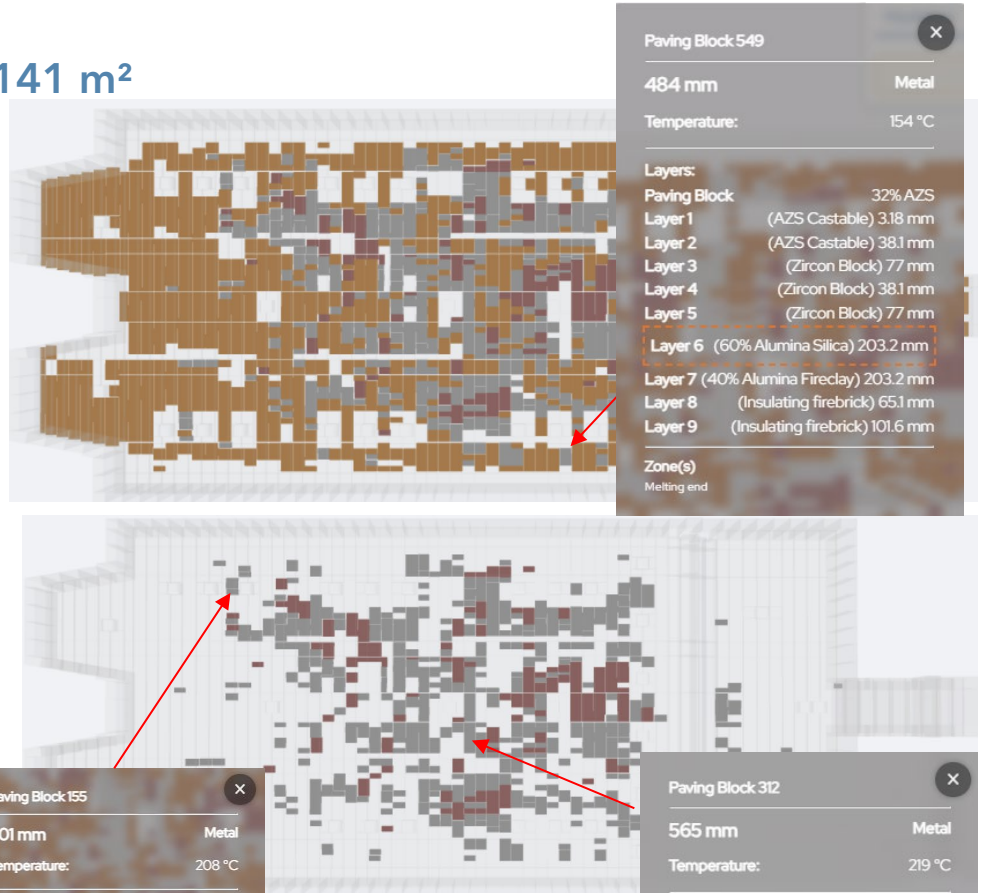
- Surface temperature is not a reliable indicator due to multi-layer insulation.
- By the time insulation temperature rises, it's too late to act and asset loss is certain.
- Radar identifies issues 2–3 years earlier than traditional inspection methods.

Temperature is a late Indicator for Metal Penetration

Glass Type: Green **Cullet:** 50% **Furnace Size:** 141 m²

No Correlation between Temperature and Metal penetration depth.

Cold face Surface Temperature (Degree C)	Remaining Insulation Thickness with metal (mm)
154	484
208	501
219	565



Extended Asset Life with Data Driven Decision

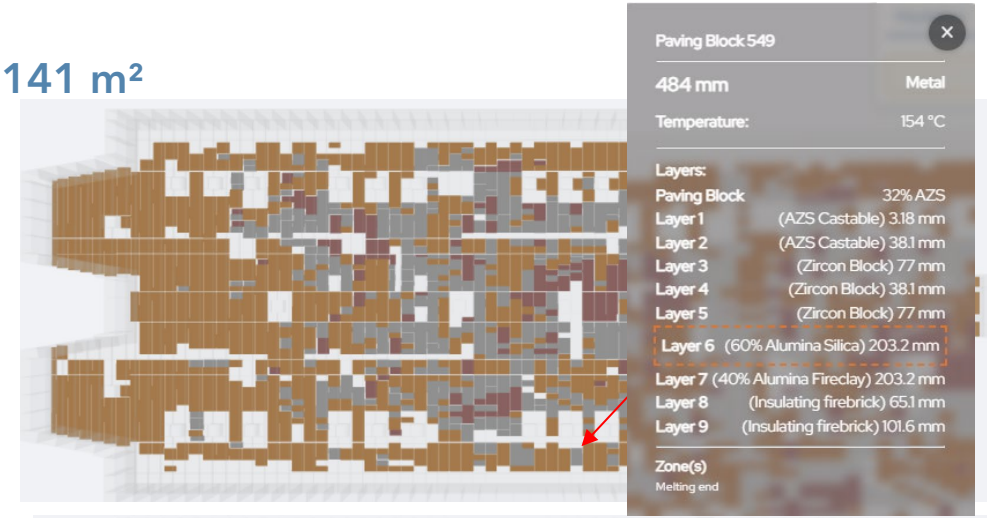
Glass Type: Green **Cullet:** 50% **Furnace Size:** 141 m²

Findings: 39% of total bottom blocks are having metal at the bottom

Furnace ran nearly 3 years **without hot bottom repair.**

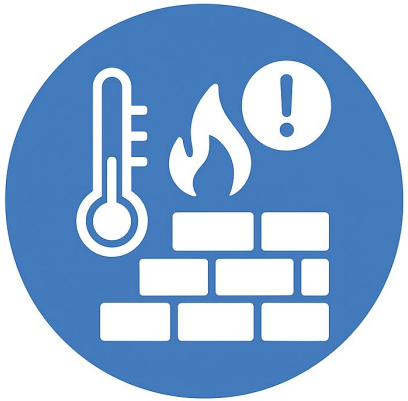
Repair performed after 3 years **from metal penetration found into insulation.**

Furnace is still in operation

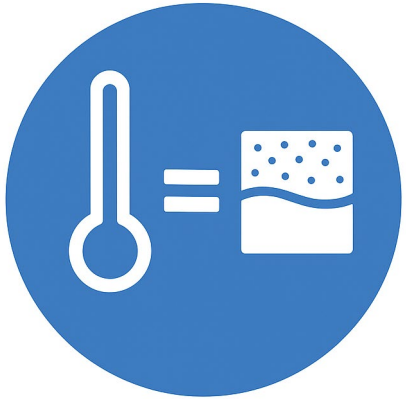


Why Temperature Fails for Glass Leak Risk Monitoring

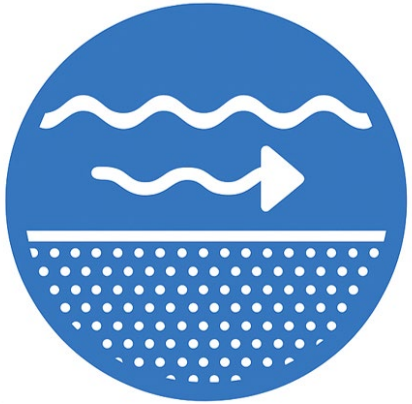
Delayed Indication



Poor Correlation between Temperature and Bottom Thickness



Hidden Infiltration and Insulation Loss



Molten glass above the bottom refractory can silently infiltrate and erode insulation beneath, without any visible surface signs. This hidden damage spreads horizontally, undermining furnace integrity while surface temperature appears normal.

Learning from the Float Furnace Bottom Monitoring

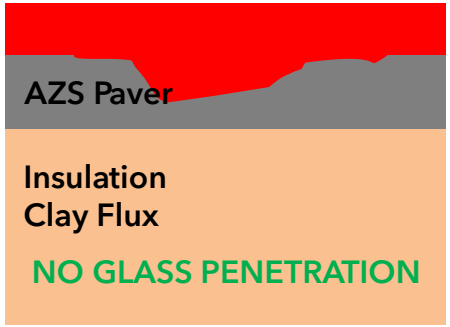
Learning from the Float Furnace Bottom Monitoring

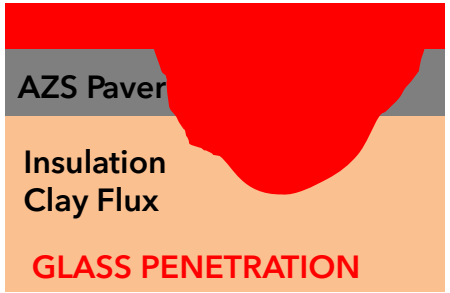
Objective: At what bottom condition the industry initiates SmartMelter® float bottom assessment

Facts about the data

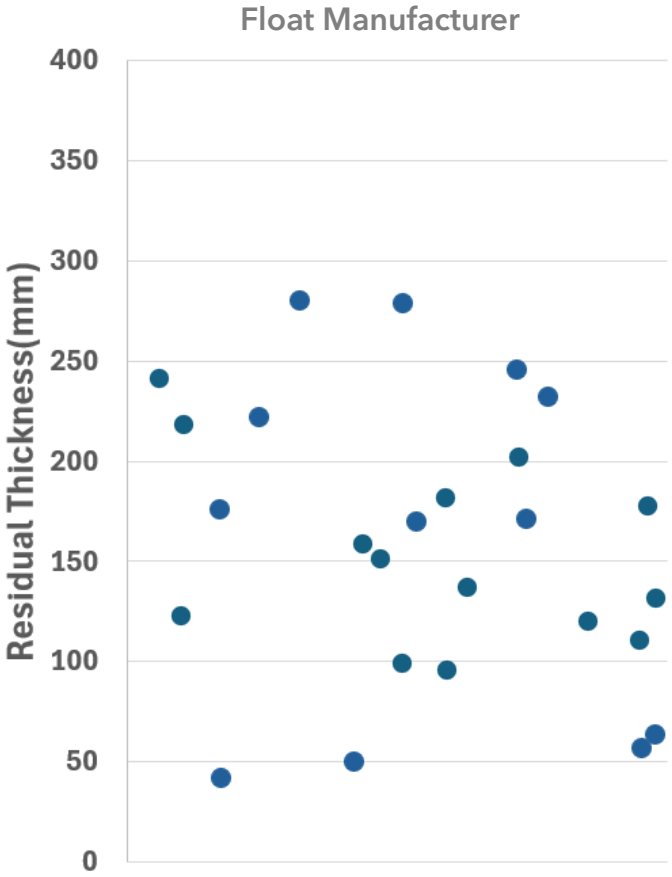
- Data Period: Sept. 2016-Oct. 2024
- First time furnace is visited-minimum observed bottom thickness
- 22 Float Manufacturers
- 80 Furnaces
- Geographically in the US, Europe, Middle East, South America, Africa and Asia

Risk Categories





Furnace Bottom Condition at First SmartMelter® Assessment



KEY OBSERVATION

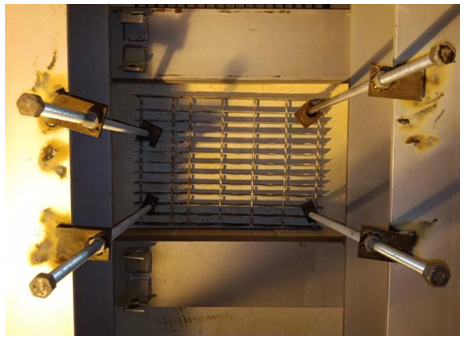
Furnaces with glass into clay flux

Data shows almost 20% of the furnaces come to us when glass is already below the pavers.

Chart shows glass infiltration into the Insulation and insulation residual thickness in mm

Maintenance Methods

Grating

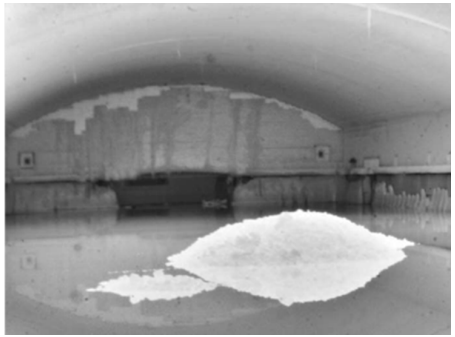


Maintenance methods chosen based on thickness criticality and desired furnace life extension

Grating + Air Cooling

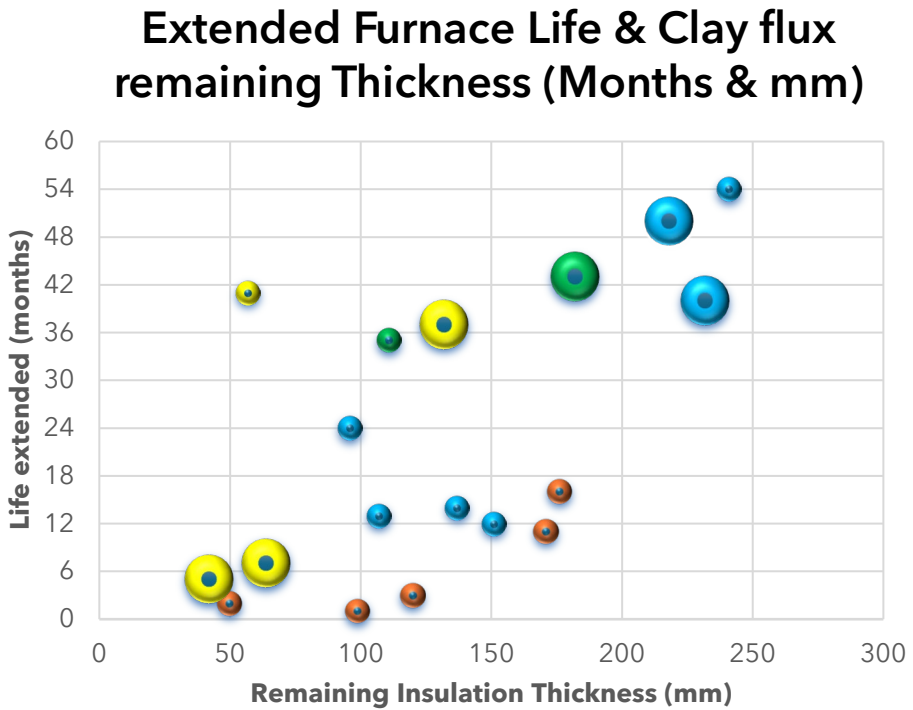
Grating + Water Cooling

AZS chips repair



Drilled Holes

Furnace Life Extension (Months) & Maintenance Type

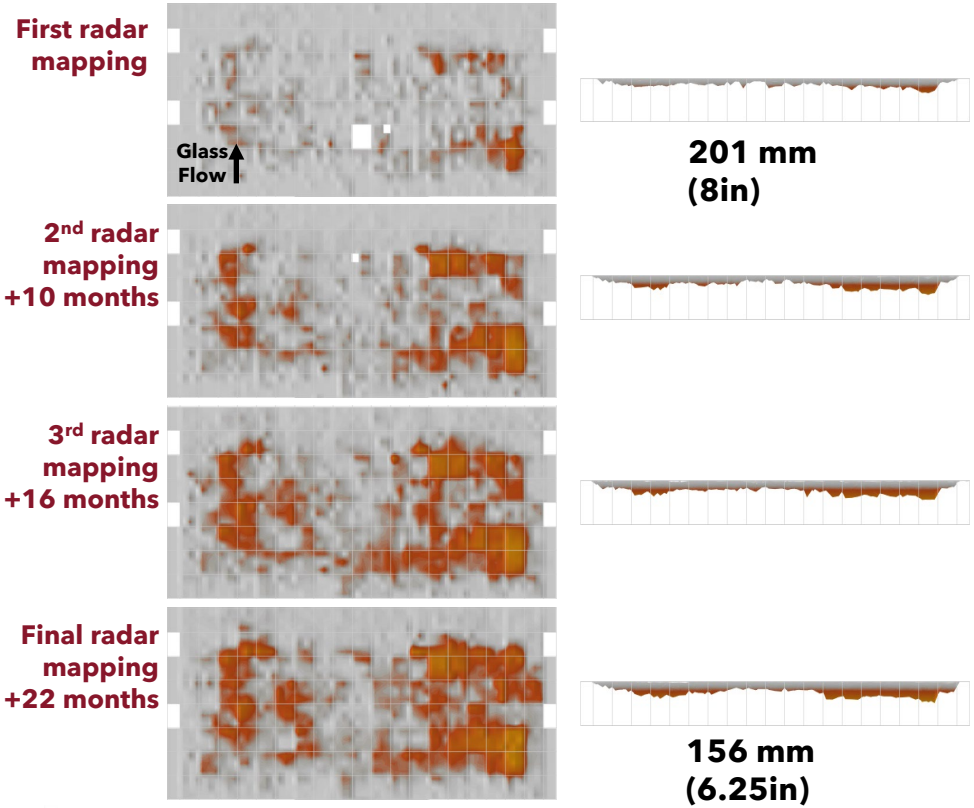


- Extensions of ≤5 months involved bottom issues and other operational concerns too.
- Large circles: Furnace is in operation currently.
- Small circles: Furnace shut down safely as per no. of months mentioned in chart.
- Different Colour Codes: Indicate maintenance type following glass infiltration into insulation.

Type of Maintenance

- No Actions
- AZS Chips repair
- Air Cooling
- Air + Water Cooling

Early Detection Helps with Slowing Wear



This furnace was monitored over 22 months.

- After nearly two years, the thinnest spot only eroded 50 mm.
- The affected area of the clay flux increased by 5 times since the first mapping.
- Air cooling was applied on the outside surface based on areas identified by 3D mapping.

Asset Life Extension on a Float Bottom

Campaign Start Date: 2008,

Expected Campaign End Date: 2027

2021: Gratings & air + water cooling added

Regular Follow-up inspections

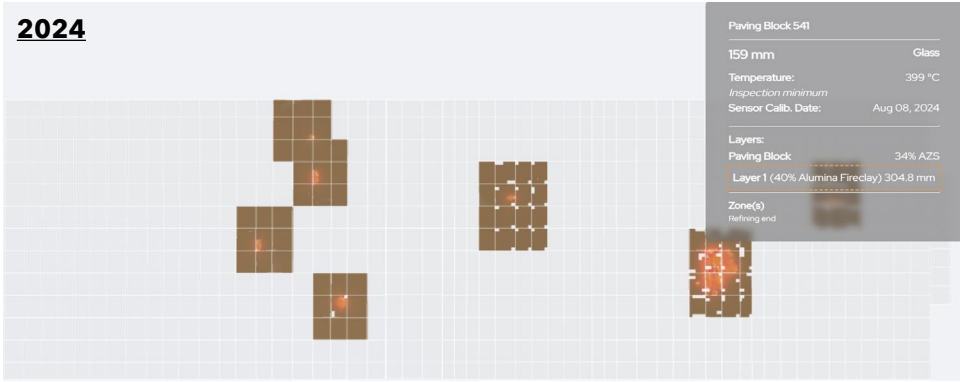
No hot repairs.

Furnace life was extended by four years and expected life increase up to six years.

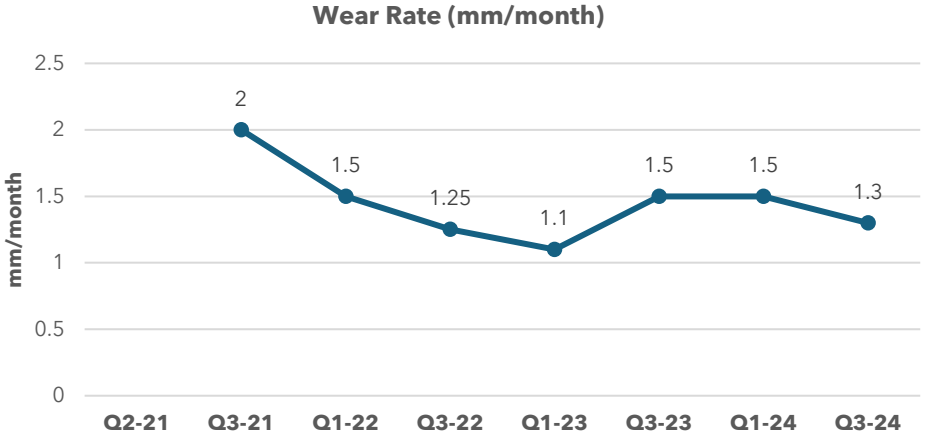
Reduced wear rates,

Minimized firefighting maintenance, and

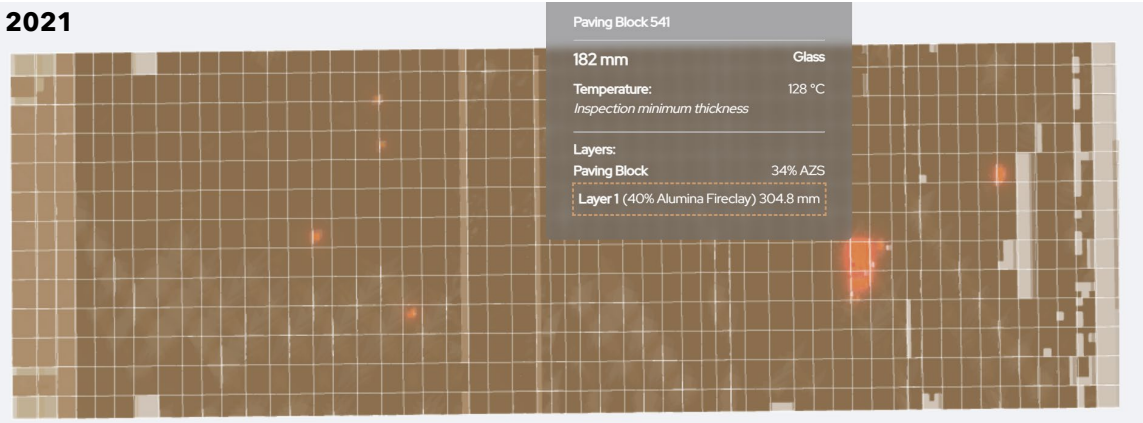
Ensured optimal glass pull stability.

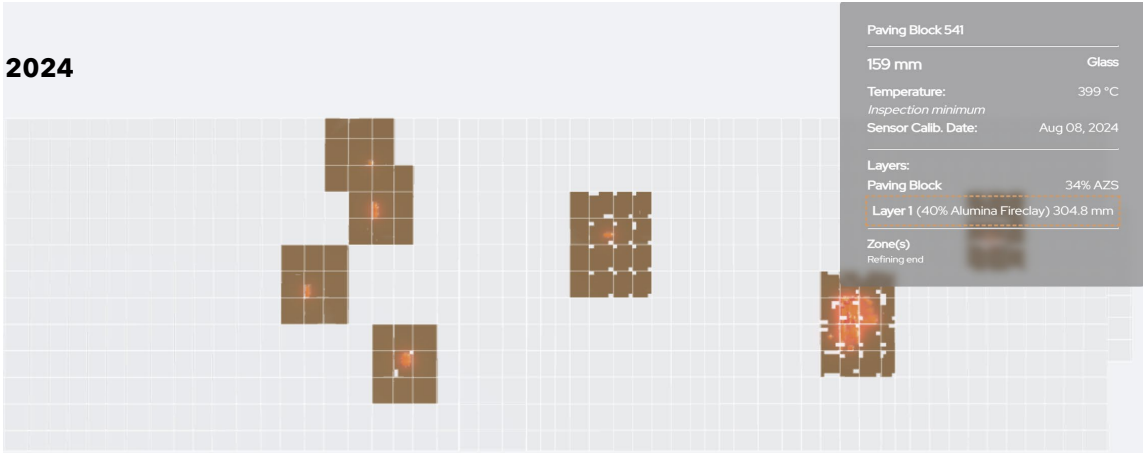


Timely and precise actions control wear rate effectively



Follow Up Inspection Results





- Targeted air- & water-cooling kept wear rates below 1.5 mm/month for 3.5+ years, ensuring safe furnace operation until 2025 scheduled repair.

Asset Life Extension in a Float Bottom

Customer implemented grating support, applied air cooling, managed wear rates, and coordinated timely AZS chip repairs.

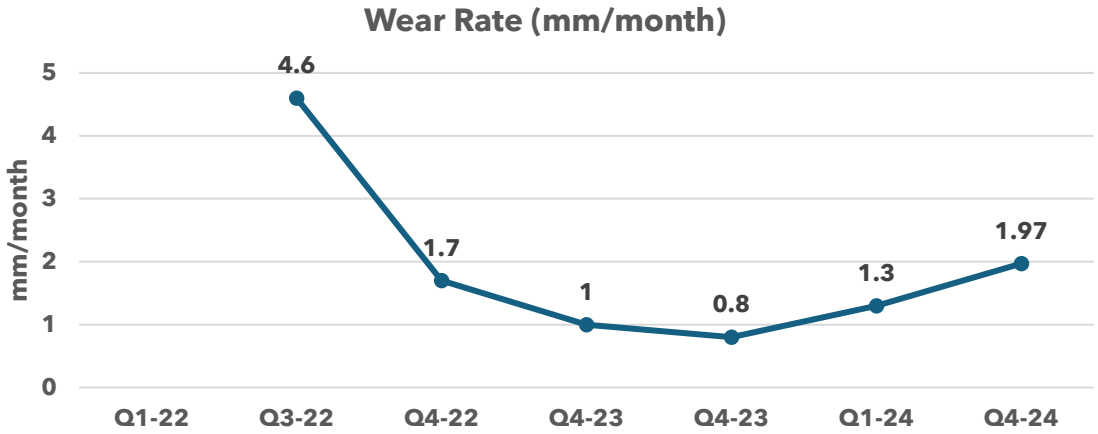
Furnace life was extended by nearly two years.

Reduced wear rates,
Minimized reactive maintenance, and
Ensured optimal glass pull stability.

Wear rate change depends on action effectiveness..

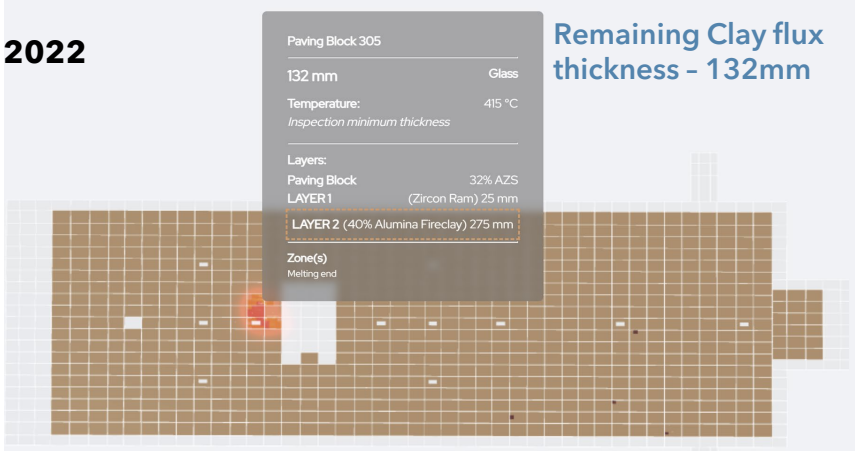
Inspection and Repair Activity Timeline:

- Campaign Start Date: 2009
- 2019: Limited Scope of Bottom Inspection – No wear observed
- 2022: Wear identified in clay flux
- 2023 & 2024: Hot bottom AZS chip repairs with defined scope
- Regular Follow-ups: 7 Inspections from 2022 to 2024



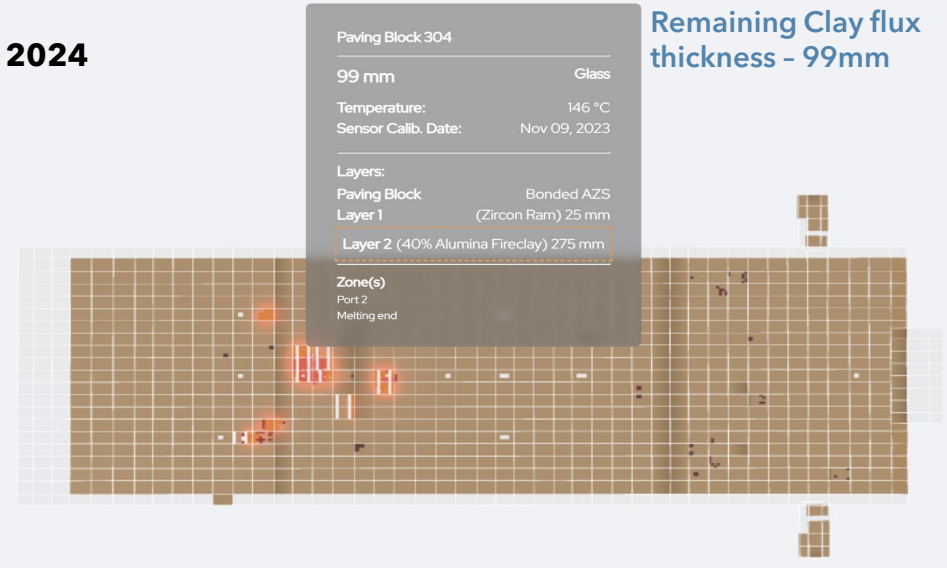
Glass Into clay flux

2022



Remaining Clay flux thickness – 132mm

2024



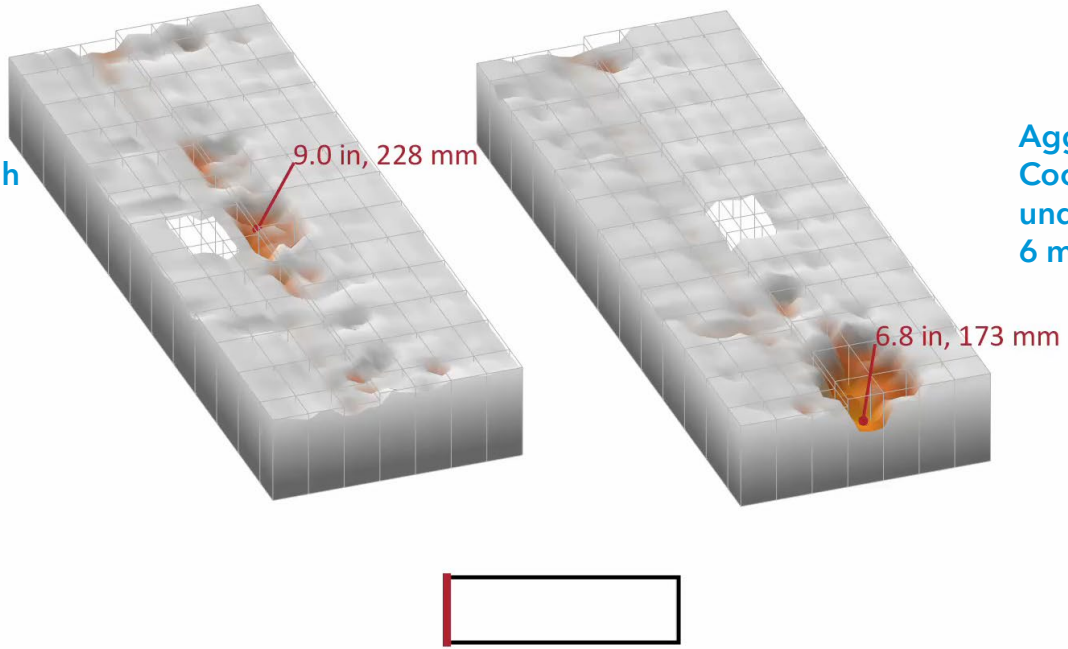
Remaining Clay flux thickness – 99mm

Early Glass Penetration Detection Saves Furnace

Traditional Cooling

Aggressive Cooling

Following Traditional Cooling – Wear rate is high and lost almost 46 mm in 6 months.



Aggressive & Focused Cooling – Wear rate under control and lost only 6 mm in 6 month.

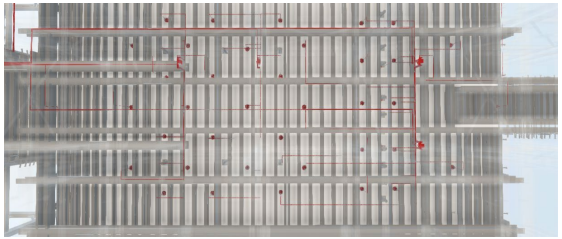
Maintenance & Expected Furnace Life Extension

Glass into Clay flux - Maintenance & Expected Furnace Life Extension

Type of Maintenance	Cost Associated with Maintenance	Pros - Cons	Expected Increase of lifetime
No Maintenance - Just Visual & Thermal Observation	No Additional Cost	Only monitoring, risk management	0 - 1 year for clear glass
Low Maintenance	<10K US$	Stoppage of bubblers (It could affect production) Reduce boosting (It could affect production) Add grating to support concerned area	0 - 1 years
Medium Maintenance	<250K US$	Cool concerned area by making holes and /or use of air lance and/or use of water	1 - 4 Years
High Maintenance	>1M US$	Hot bottom repair - using AZS chips Hot bottom repair - cast concrete	2 - 5 Years

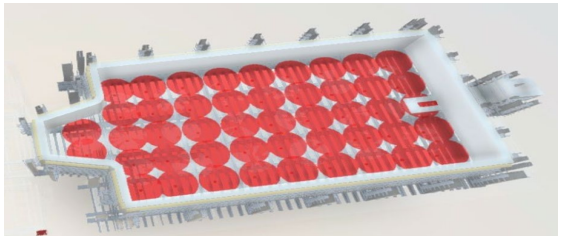
Technology:
Online thickness monitoring - Polaris™

Control Box



Sensor Network in Furnace Bottom

Sensor at Metal Line



Furnace Bottom Area Continuously Monitored

Description:

Polaris™ IoT Refractory Sensor System: Permanent sensor enables continuous real-time radar monitoring of refractory thickness in high-risk areas—sidewall, bottom, and throat.

Why it Matters?

1. Real-time Feedback on Impact of Furnace Operations on Refractory Life
2. Risk Management for Bottom
3. Benchmark Process History
4. Optimize Quality, Lifespan, and Energy consumption: Maintain output with less refractory wear

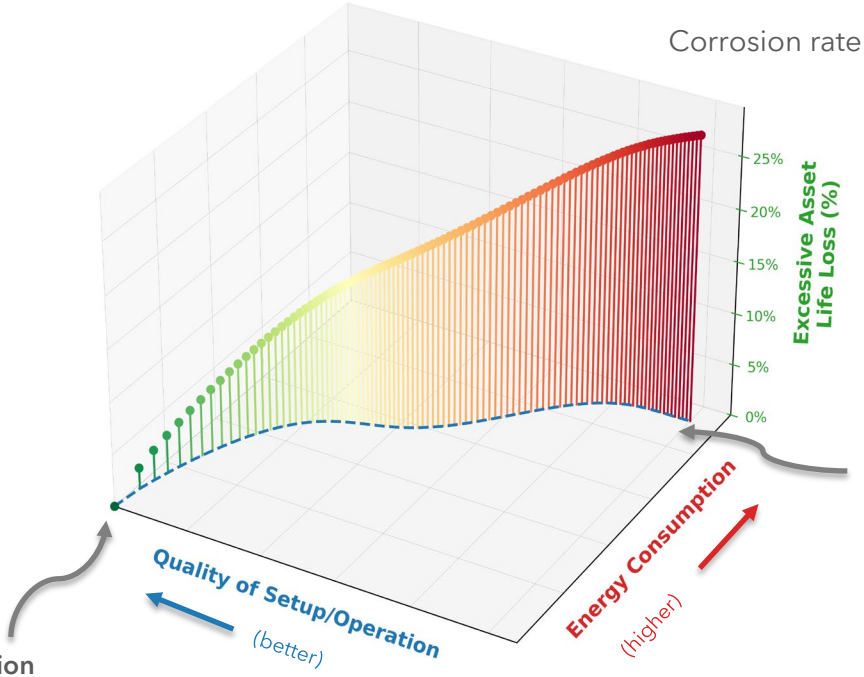
Key Business Outcomes:

- Improved Furnace Life
- Improved Furnace Operations
- Lower Energy Consumption

Asset Life Optimization

Asset life is frequently overlooked by engineers in day-to-day furnace operation.

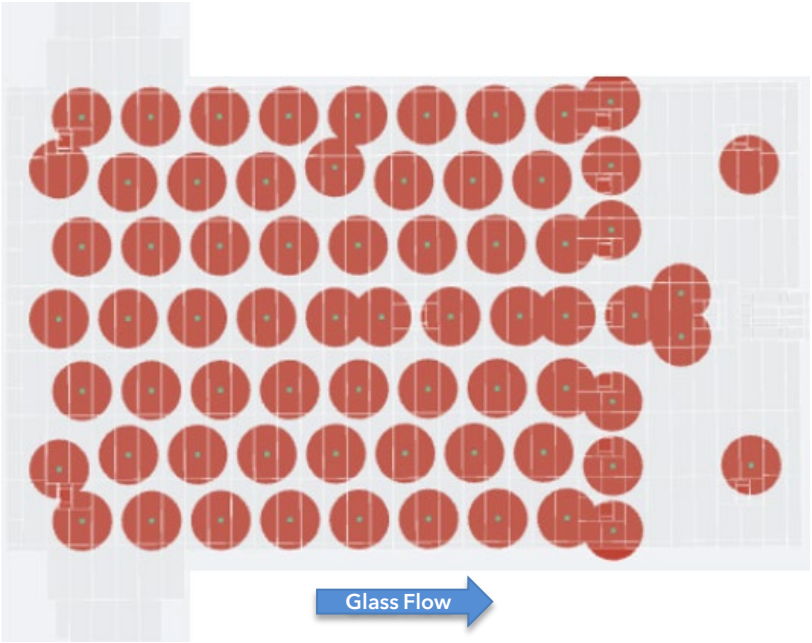
Corrosion rate doubles for every ~ΔT = 50°C



Improper setup & operation
necessitates higher energy consumption to produce the same glass quality

Proper setup & operation
ensures low energy consumption

Online - Polaris™ Layout Examples & Disclaimer



Polaris™ IoT Refractory Sensor System: Permanent sensor provides continuous real-time radar monitoring of refractory thickness, deeper than portable sensors

Detects through ramming mix up to the cold face of the paving.

Advantages

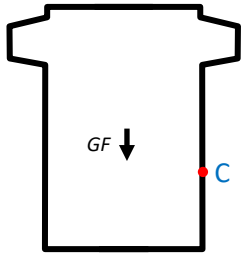
1. Real-time feedback on furnace operation impact on refractory life (e.g., metal infiltration, wear).
2. Deeper visibility due to continuous data
3. Wear rate can be tracked and compared with operational changes.
4. Coverage can be achieved 80 – 90% of the bottom.

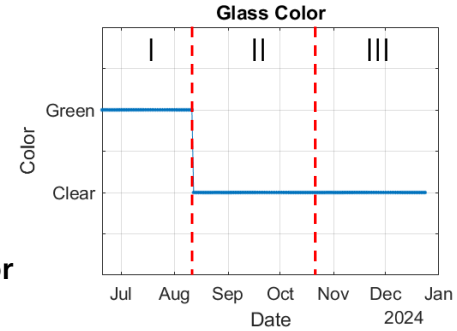
Note: Red circle in bottom layout show Polaris coverage.

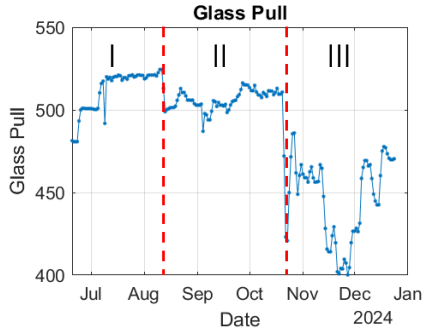
Online Wear Analysis on an Operational Furnace

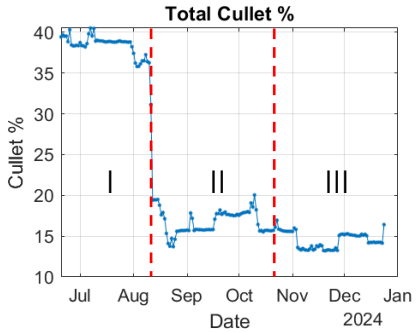
Furnace process data from July 2024 to January 2025
I. Green glass at about 100% pull
II. Clear glass at about 100% pull and 90°C increase in temperature from Period I
III. Clear glass at about 80% - 90% pull and 80°C increase in temperature from Period I

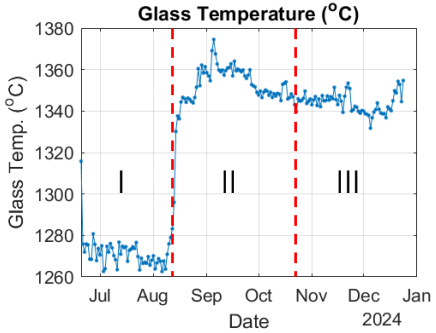
Left sidewall sensor



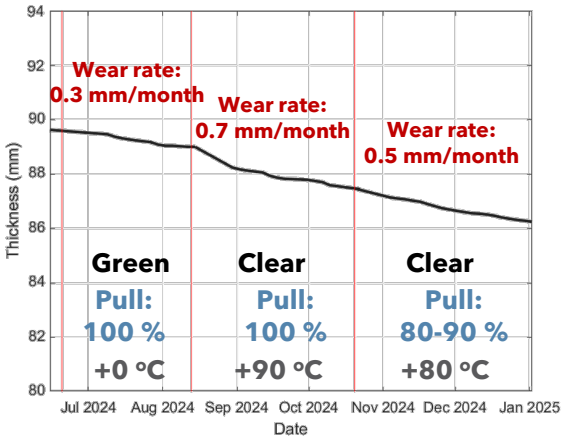








AZS Residual Thickness Over Time

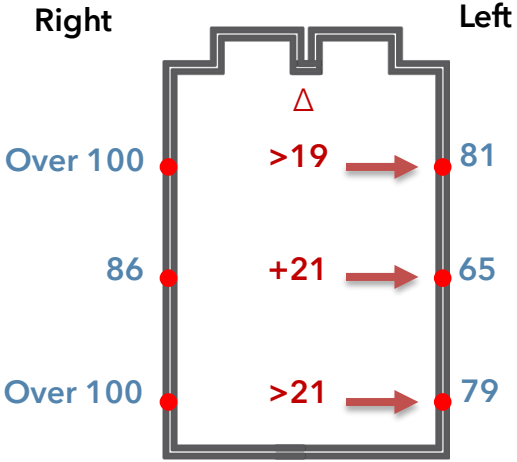


Leveraging Online Thickness Data: Uneven Wear

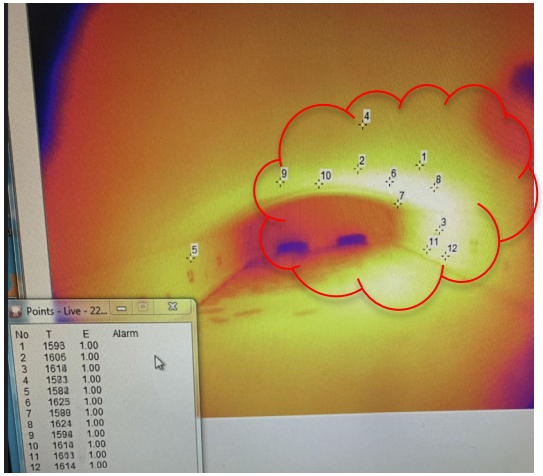
Severe left-side wear discovered with refractory thickness monitoring

Cause: Imbalanced sidewall cooling and imbalanced internal temperature

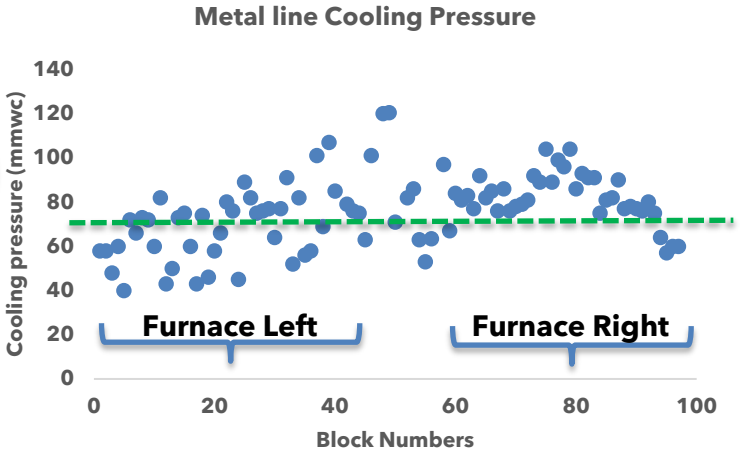
Actions: Cooling improvement and temperature optimization following optical temperature



Metal line residual thicknesses in mm



+40 Degree C Temperature at left side of the furnace



Lesser cooling at left sidewall

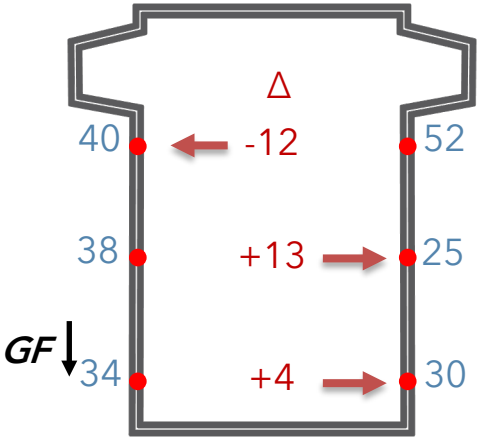
Leveraging Online Thickness Data: Uneven Wear

Moderate downstream and upstream wear imbalance discovered in Polaris™ data

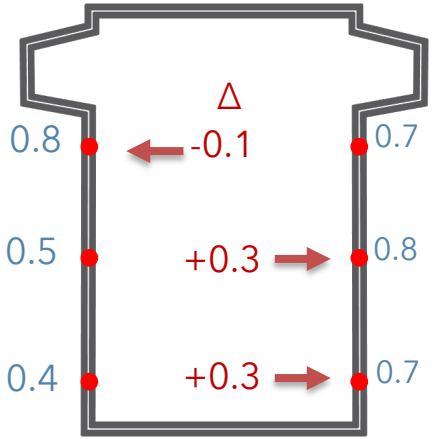
Equal and adequate sidewall cooling on both sides was found

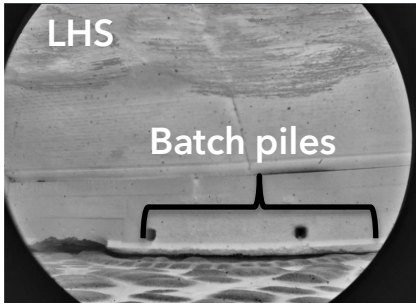
Batch piles found to be progressing far downstream and against left side, causing higher wear

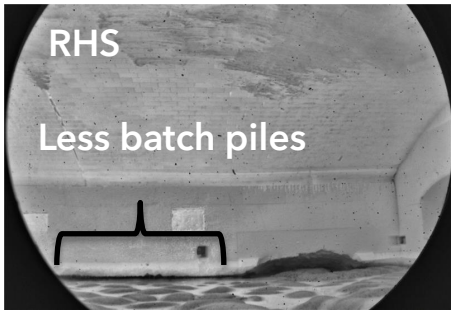
Residual thickness mm



Current wear rates mm/month







Conclusion

Traditional indicators such as temperatures are not enough

Early detection = Cost savings + Operational stability

Polaris™ data empowers actionable insights

Real-world results: Up to 6 years of life extension

Temperature Papers

Download our Paper:
Temperature Part 1
An Unreliable Indicator of Refractory Wear

Download our Paper:
Temperature Part 2
A Late Indicator of Glass Penetration

Mohit Gohel

mohit.gohel@paneratech.com

4035 Ridge Top Road
Suite 510
Fairfax, VA 22030 USA
+1 (703) 719-9666
+919727768313