



What Temperature Can't Tell You: How Real-Time Wear Data Drives Better Furnace Decisions

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PaneraTech today: U.S. company with global reach and manufacturing depth



Global footprint



HQ Office



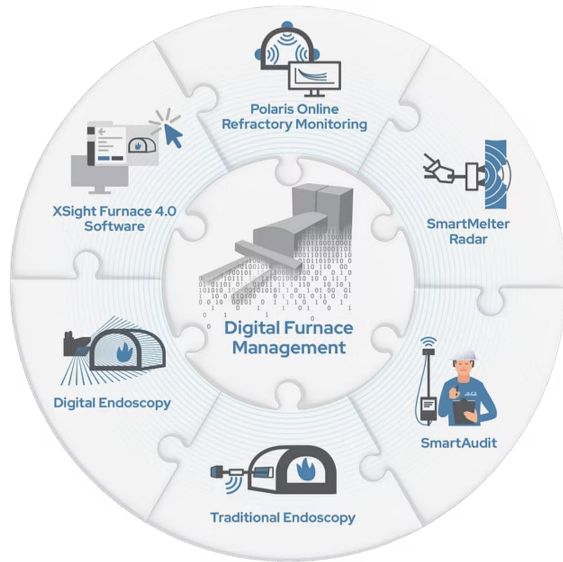
Engineering and Manufacturing Center



Data Science and Software

Headquartered in Northern Virginia, USA

- ~100 employees globally
- Teams in the USA, Portugal, Italy, France, Germany, Türkiye, India, and China
- Engineering, manufacturing, data science, and software integrated under one operating model



Data-Driven Manufacturing Services

Transform your industrial operations with intelligent monitoring solutions that optimize furnace performance, extend asset life, and reduce costs through precision refractory management.

Two approaches to refractory monitoring

Temperature-based refractory monitoring

Temperature -based

WEAR RATE MEASUREMENT

Cannot measure wear rate directly —temperature shifts hide it.

INSTALLATION

Needs day-one baseline; blind at the metal line (thermocouple distorted by cooling and overcoat).

WEAR -PATTERN COVERAGE

Blind at the metal line and in hybrid furnaces —foam accelerates wear that temperature cannot see.

OPERATIONAL INSIGHT

Pull rate and glass color changes shift the temperature signature —reference is lost, signal becomes unreliable.

STRATEGIC VALUE

Estimate remaining thickness from temperature readings.

Polaris™

Wear rate measurement & thickness (radar)

WEAR RATE MEASUREMENT

Direct wear rate in mm/month —the only metric that exposes how fast you're losing the furnace.

INSTALLATION

Installs at any time; works at the metal line, center block, throat, bottom and electrode blocks.

WEAR -PATTERN COVERAGE

Tracks wear rate across metal line, center block, throat, bottom and electrodes —simultaneously, in real time.

OPERATIONAL INSIGHT

Follows process changes; supports operational actions to slow the wear rate.

STRATEGIC VALUE

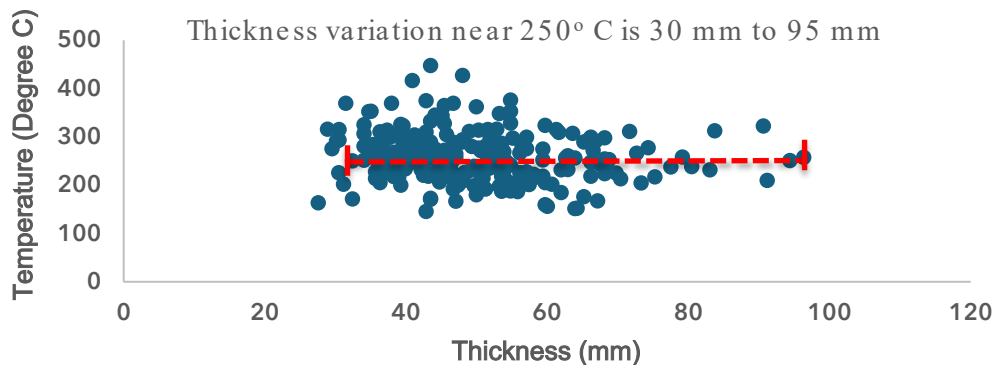
Slow the wear rate, extend furnace life by months —turning every operational decision into measurable ROI.

Temperature is a warning light. Wear rate is the speedometer.

Temperature fails for maintenance decision

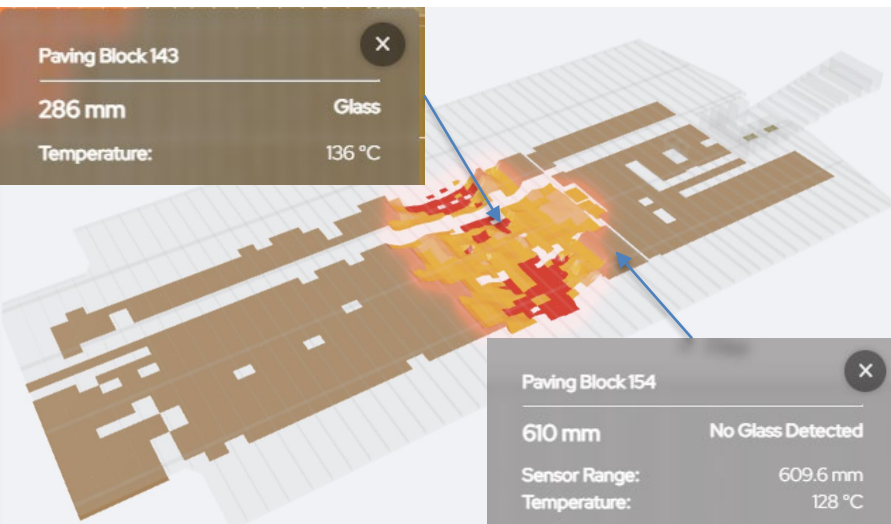


Temperature (Degree C) Vs Thickness (mm)



- Scatter plot analysis shows no strong correlation, highlighting the need for direct thickness measurement to guide maintenance decisions.
- Surface temperature is not a reliable indicator of refractory thickness.
- A 33 mm thickness difference exists despite similar temperatures (~310 °C).

Temperature is a late Indicator



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.

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

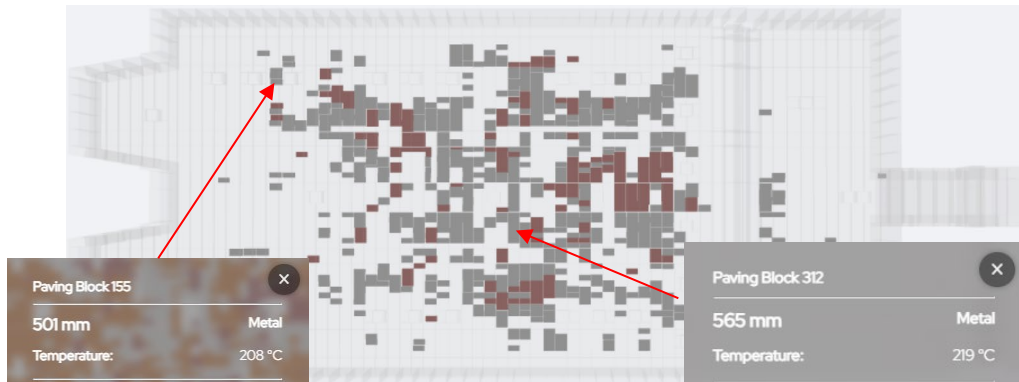
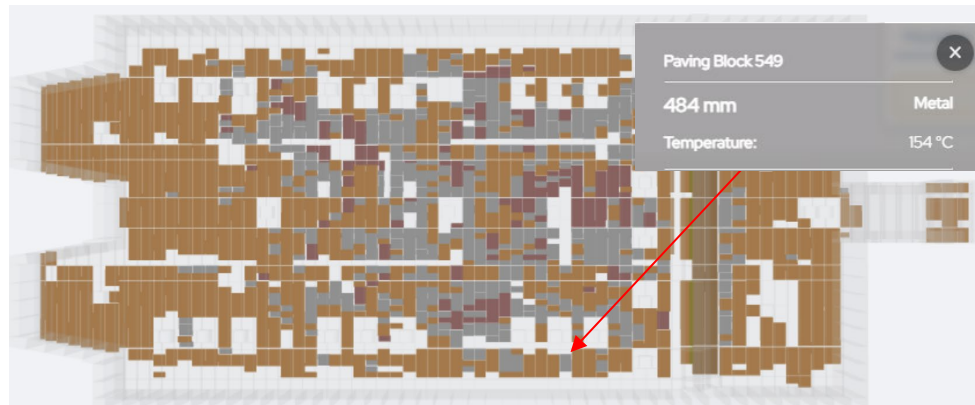
Temperature is a late Indicator for Metal Penetration

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)
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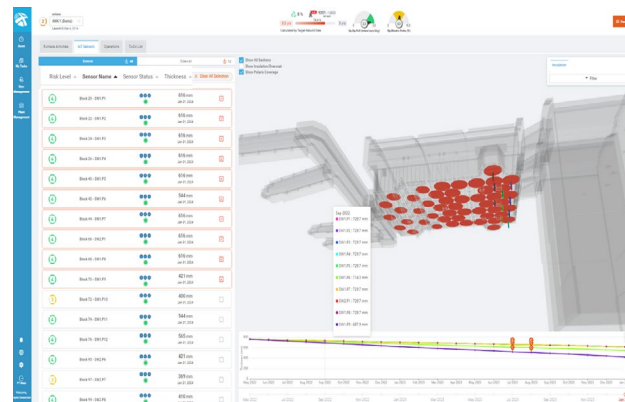
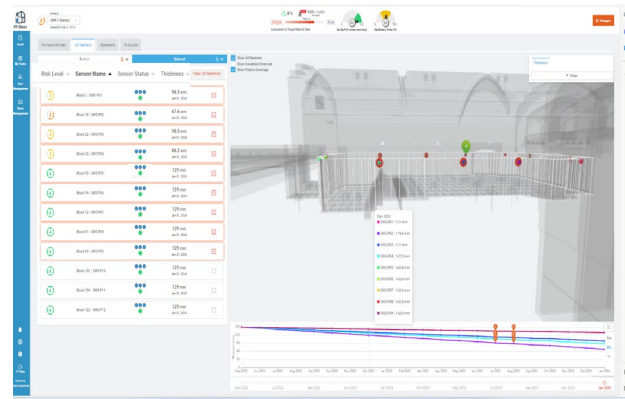
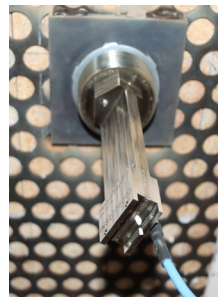
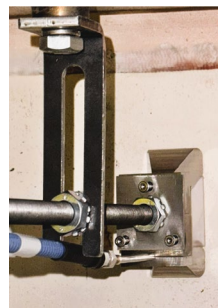
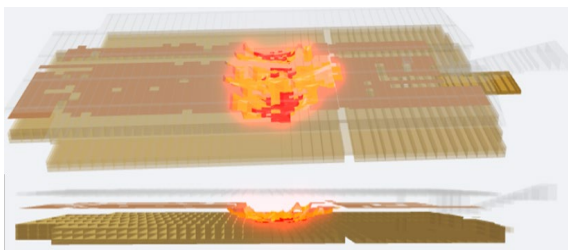
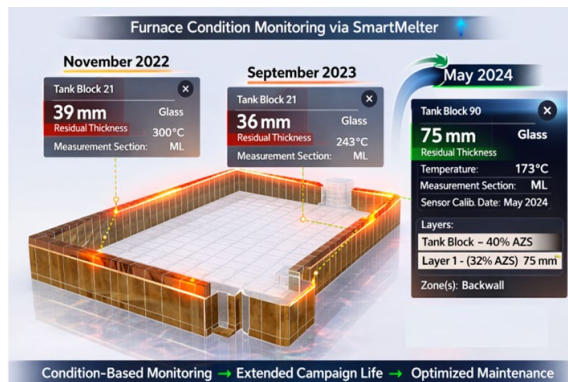
154	484
208	501
219	565



Technology creates visibility across refractory condition, operations, and risk

Radar visibility

Refractory thickness and wear patterns become quantified.





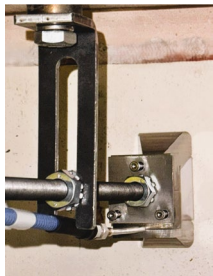
Polaris™ Continuous and Reliable Furnace Monitoring

Permanent IoT sensor system enabling continuous radar monitoring of refractory thickness in high -risk areas—delivering real -time operational insights and proactive risk management.

Polaris™ at Sidewall



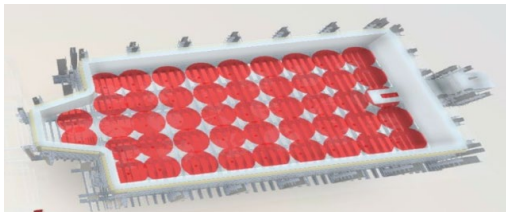
Sensor Network in Sidewall



Polaris™ at Throat



Polaris™ at Bottom



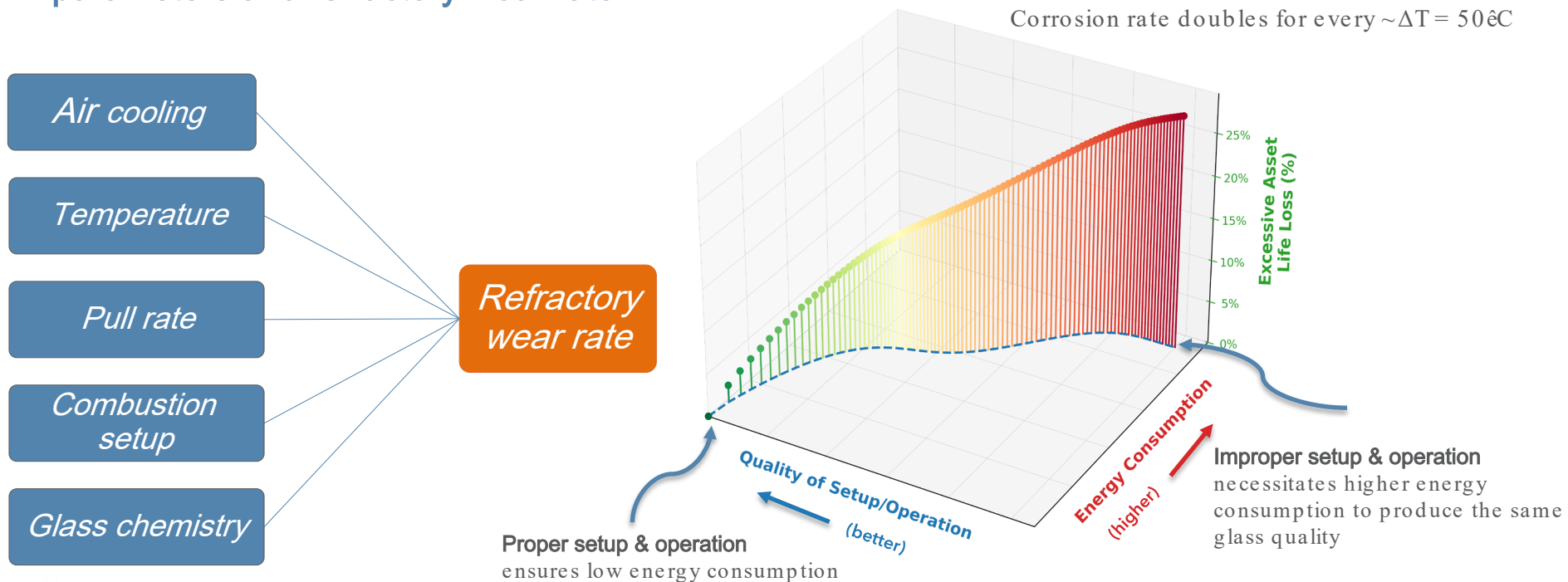
Furnace Bottom Area Continuously Monitored





Polaris™ –Tool for Asset Life Optimization

Polaris™ data to provide insights into the relationship between furnace operational parameters and refractory wear rate.





Polaris™ Wear Analysis on an Operational Furnace

Key Insight: Temperature elevation significantly accelerated wear during clear glass production, increasing degradation by 133% compared to baseline green glass operations.

Furnace Campaign: July 2024 –January 2025

01

Period I: Green Glass
100% pull rate, baseline temperature
Wear rate: 0.3 mm/month

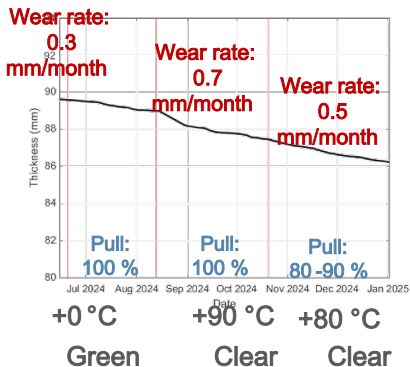
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Period II: Clear Glass
100% pull, +90 °C temperature increase
Wear rate: 0.7 mm/month

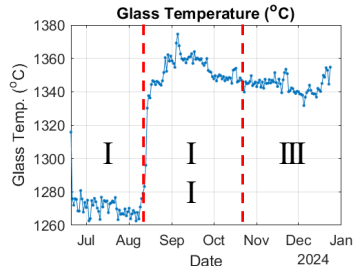
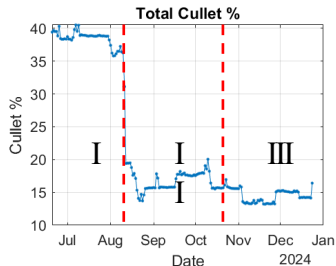
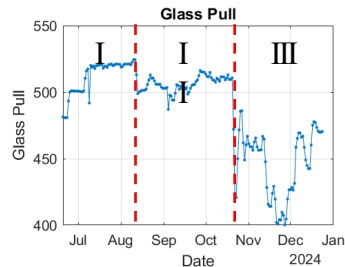
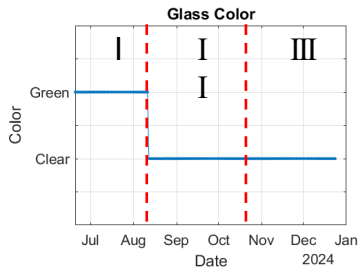
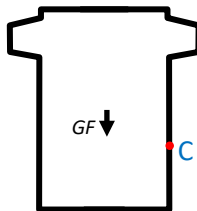
03

Period III: Clear Glass
80-90% pull, +80 °C temperature increase
Wear rate: 0.5 mm/month

AZS Residual Thickness Over Time



Left sidewall sensor



Reversing 4 Years of Wear in a 2-Year-Old Furnace...

Background:

- A 2-year-old oxy-fuel furnace producing high -quality glass at full pull rate.
- No alarms raised; on the surface, the plant appeared to be performing optimally.
- A PaneraTech Polaris audit revealed a "Physical Age" of 4 years despite a "Chronological Age" of only 2.

The Challenge

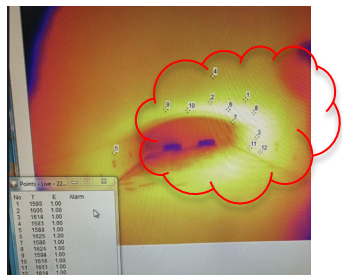
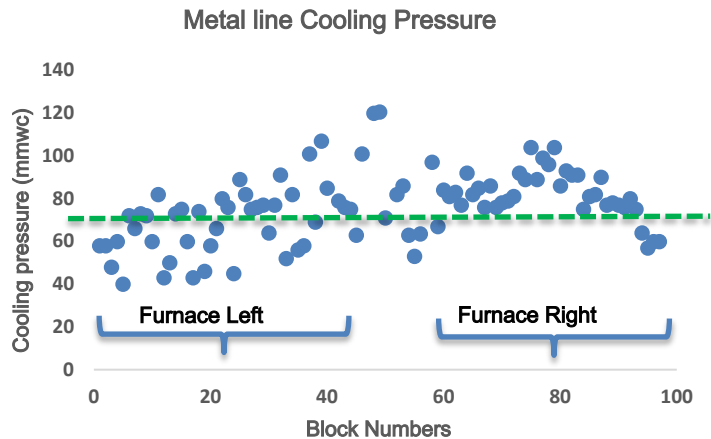
- The left side of the furnace was wearing twice as fast as the right, showing a +40 °C temperature spike and significant thickness loss.
- How do we stop the accelerated ageing and still make good quality glass?

The Solution

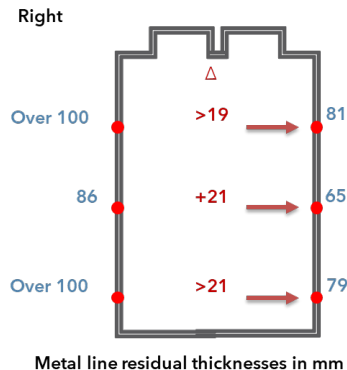
- PaneraTech's Asset Management team identified that the wear was caused by an inexperienced workforce.
- Workforce unfamiliar with the nuances of colored glass and inadvertently creating excessive foam
- PaneraTech educated the plant staff on colored glass dynamics and optimized production settings to reduce foaming..

The Outcome

- Kept the same quality glass but at \$0.5M lower cost
- Furnace is no longer ageing faster than reality
- Upskilled the workforce and integrated data driven manufacturing



+40 Degree C Temperature at left side of the furnace



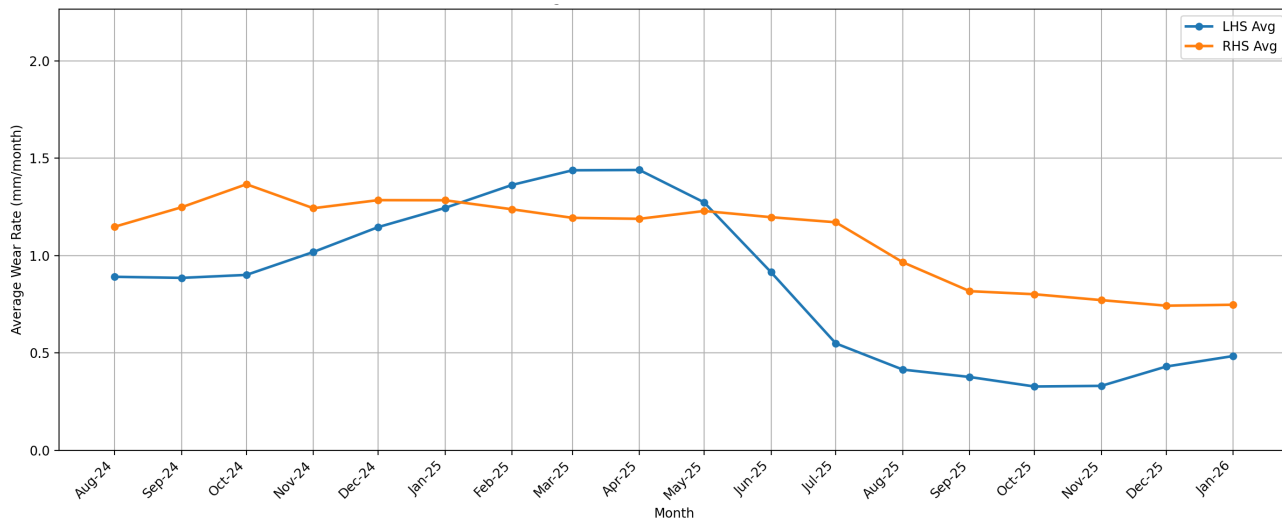


Data-driven use of sensors

From audit to actions: PaneraTech and the plant team optimized operations by reducing foam, standardizing combustion process, and adjusting cooling air pressure.

Business outcome: Prevented further asset life loss. Crown and bottom temps reduced by 50°C and 15°C, respectively.

Further accomplishment: monthly follow-up, reinforce practice using technology

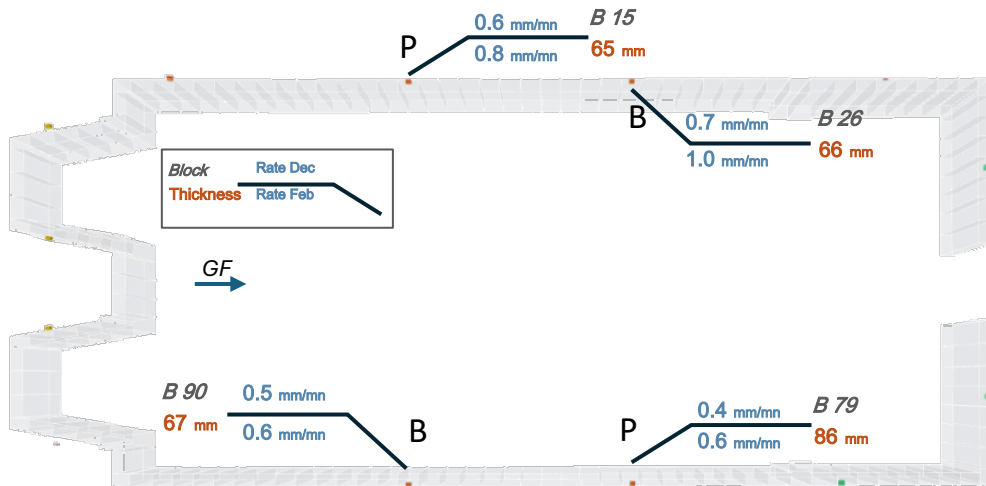


Average Wear Rates: Left Vs Right



Lowering pull could cost you more than expected

This is the situation many customers faces today. A container furnace cut pull 50% in response to soft demand. With no compensating cooling or combustion adjustment, sidewall wear rate increased by ~40%.

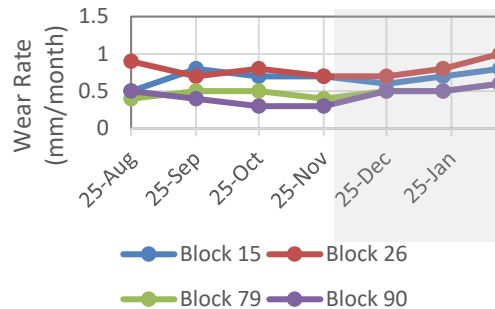


Wear rates (mm/month) over time

	Block 15	Block 26	Block 79	Block 90
25-Aug	0.5	0.9	0.4	0.5
25-Sep	0.8	0.7	0.5	0.4
25-Oct	0.7	0.8	0.5	0.3
25-Nov	0.7	0.7	0.4	0.3
25-Dec	0.6	0.7	0.5	0.5
17-Feb	0.8	1	0.6	0.6

Changes from December to February

Block 15	Block 26	Block 79	Block 90
+33%	+43%	+20%	+20%



Additional 90 tons should not wear the furnace 50% faster...

Background:

- Float glass customer needed to increase production by 90 tons
- Customer was already using PaneraTech Polaris solution
- Polaris indicated that the wear rate would increase by 50% if they moved ahead with the additional production

The Challenge

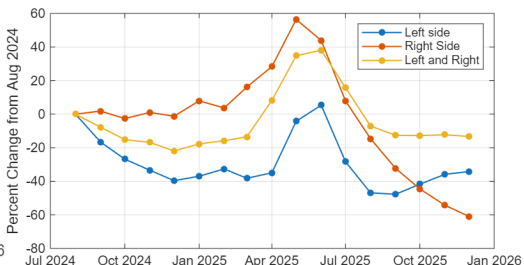
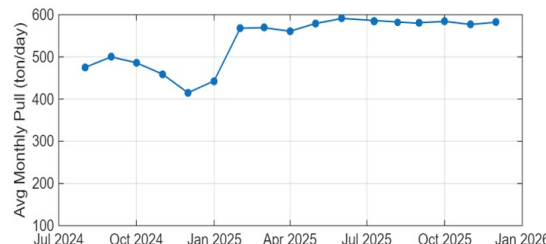
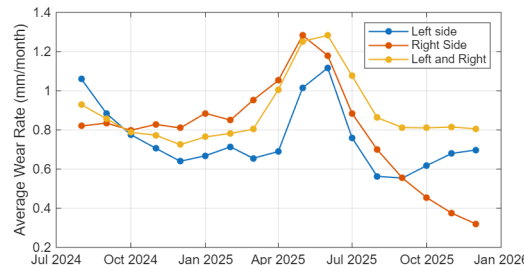
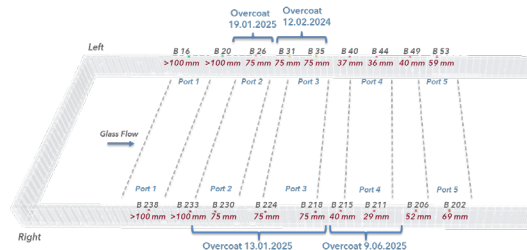
- How to increase my pull rate by 90 tons without impacting the furnace wear rate

The Solution

- PaneraTech's Asset Management team worked with the plant to make changes to the charger and combustion settings

The Outcome

- Wear rate decreased by 50%, back in line with previous production quantity
- Customer able to increase pull rate by 90 tons without negatively impacting the furnace





Chemistry changes can significantly impact furnace wear

Background:

- Float furnace operating under stable conditions (pull, temperature, operations unchanged)
- Controlled adjustment of glass chemistry: Na_2O reduced by -0.4%
- Polaris monitoring used to track refractory wear before and after change

The Challenge

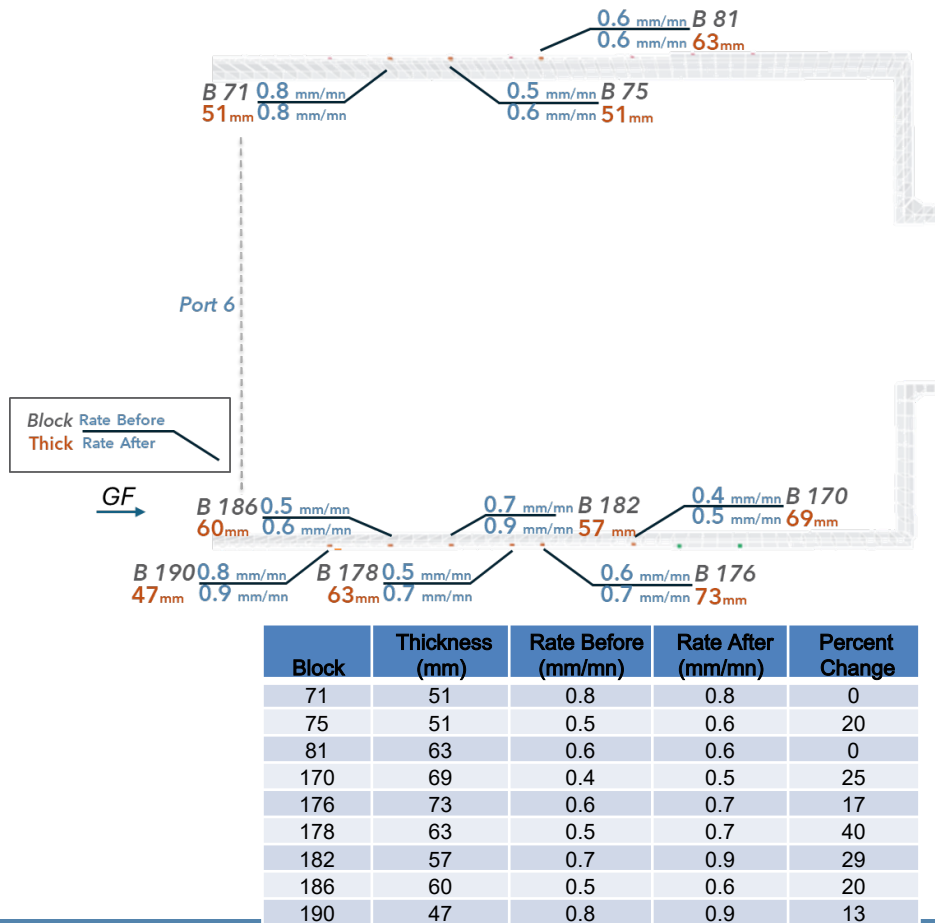
- Understand how minor chemistry adjustments impact refractory wear
- Limited visibility between glass composition and asset degradation
- Risk of unintended costs from changes driven by cost optimization

The Solution

- Compare wear rates before and after Na_2O reduction using Polaris data
- Isolate chemistry as the only changing parameter

The Outcome

- Wear rate increased up to +40% despite stable operations
- Demonstrates strong sensitivity of refractory wear to glass chemistry
- Highlights hidden risk: batch changes can accelerate asset degradation



Conclusion



Traditional indicators such as temperatures are not enough



Early detection = OPEX savings + Operational stability + CAPEX delay.



Polaris™ data empowers actionable insights for operation management.

Temperature is a warning light. Wear rate is the speedometer.

Publications



Temperature (part 1) –An unreliable indicator of refractory wear



Temperature (part 2) –A late indicator of glass penetration



Polaris™ - Direct wear rate measurement for Glass Furnaces



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