

"Decarbonization for the Sustainable Glass Industry"

New Melting Technologies Require Updated Monitoring Methods



THE ALL INDIA GLASS MANUFACTURERS' FEDERATION

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RELIABLY MAKE MORE GLASS

PaneraTech

New Melting Technologies

- All-Electric
- “Hybrid” Melters
- Hydrogen
- Increased PCR cullet

New Melting Technologies

- What do these new technologies change for refractory monitoring?

For you,
Everything!

All-Electric

- New operations during first campaign
- Foam at high cullet percentages
- Shorter campaigns
- New corrosion patterns for container glass
- Safety aspects when monitoring refractories

All-Electric Safety Aspects

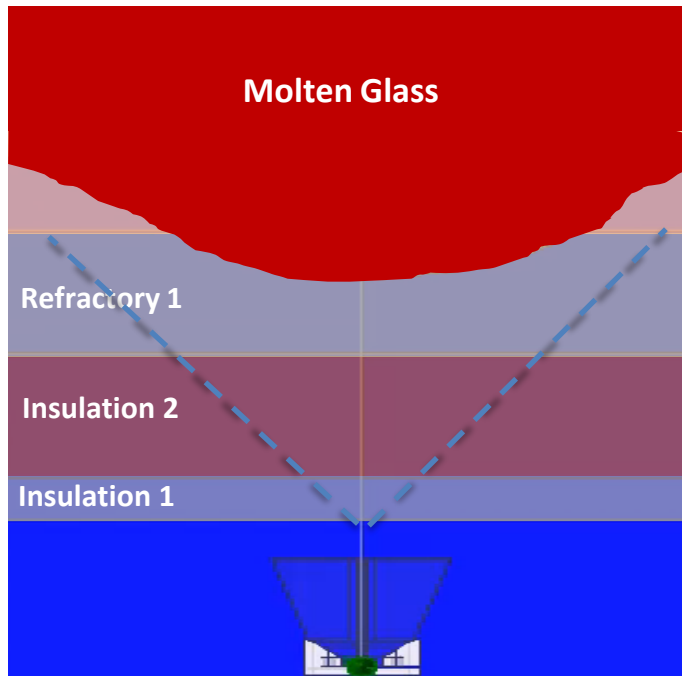
- Is it safe to touch the furnace while in operation?
- Will there be safety cages to prevent personnel from going under the furnace?
- Physical measurements (hooks) only practical with boost off
- Pushing Electrodes / Changing Holders

SmartMelter Reminder

- SmartMelter utilises portable radar sensors to measure refractory thickness non-invasively.



Key Technology: Radar Thickness Sensor



Radar technology identifies potential furnace failure points and glass leaks 1-3 years in advance in comparison to human eye and thermal sensors.

SmartMelter® Sensors in Operation



SmartMelter Results

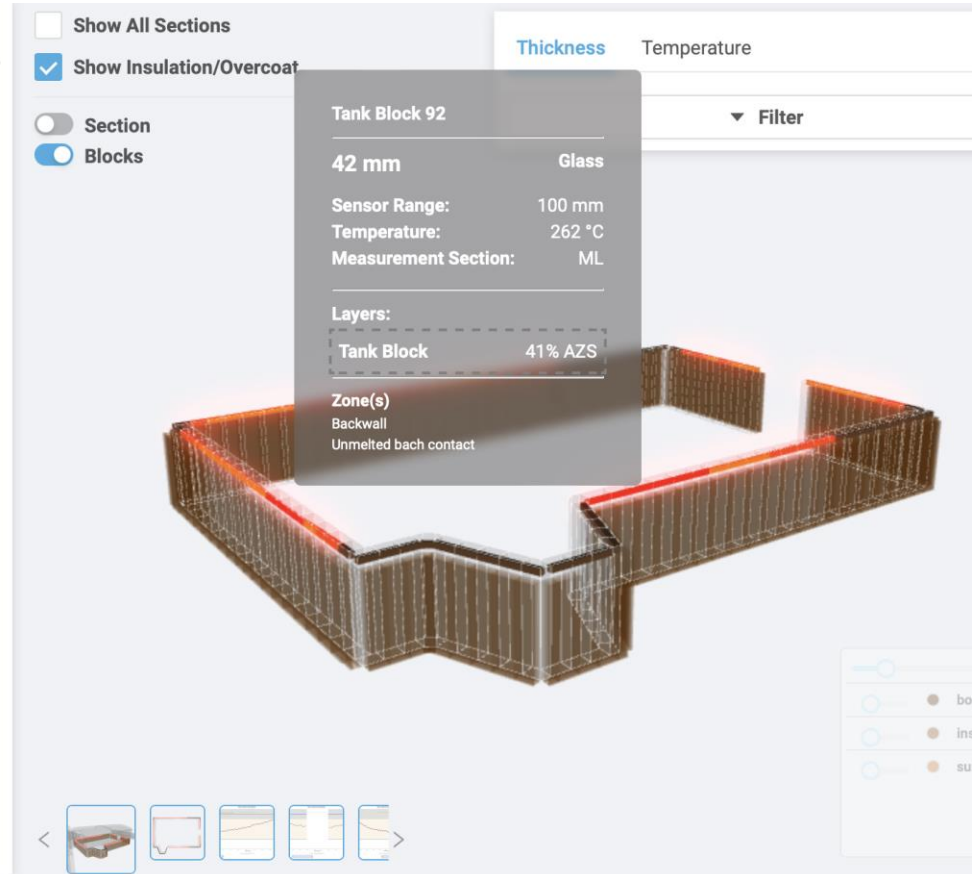
Metal Line Thickness Results

SmartMelter Results Below 40 mm Remaining Thickness

- Block 9 - 38 mm
- Block 10 - 38 mm
- Block 66 - 39 mm
- Block 67 - 40 mm
- Block 68 - 34 mm
- Block 69 - 38 mm
- Block 92 - 39 mm
- Block 93 - 40 mm

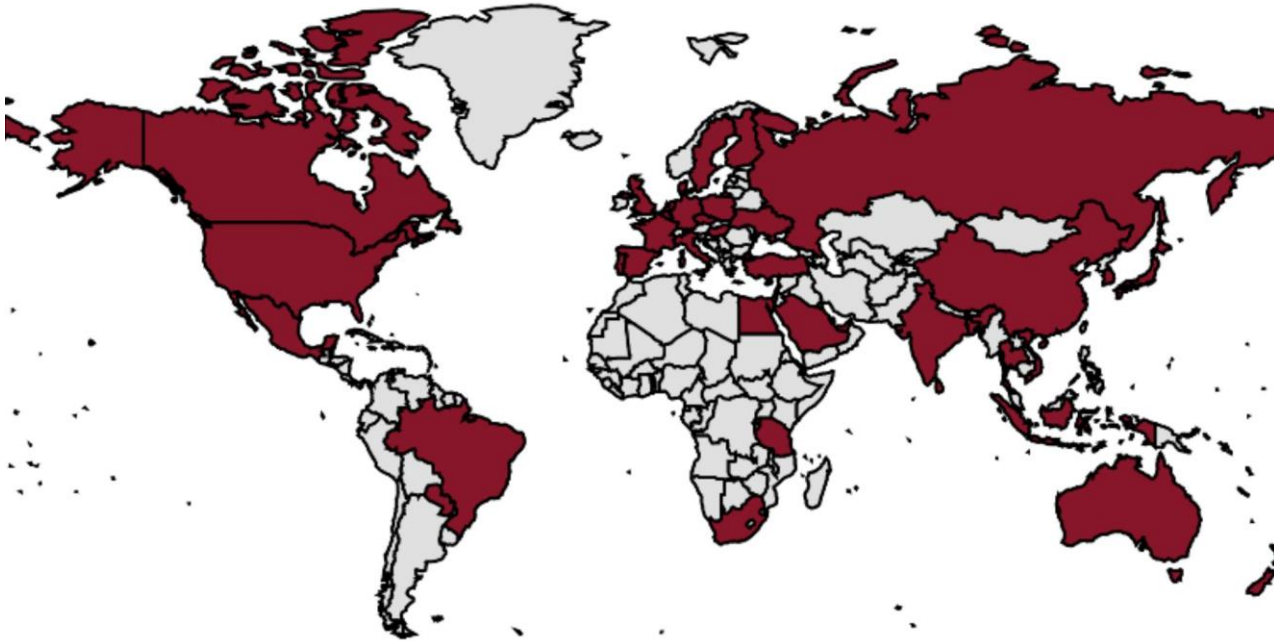
SmartMelter Results Below 50 mm Remaining Thickness

- Block 7 - 50 mm
- Block 8 - 45 mm
- Block 11 - 41 mm
- Block 12 - 45 mm
- Block 13 - 48 mm
- Block 14 - 49 mm
- Block 63 - 50 mm
- Block 64 - 47 mm
- Block 65 - 41 mm
- Block 70 - 44 mm
- Block 91 - 44 mm
- Block 94 - 42 mm
- Block 95 - 50 mm



Widespread Adoption in the Glass Industry

Since 2017, we have performed projects in 40 countries



How does SmartMelter handle Electric Melting Now?

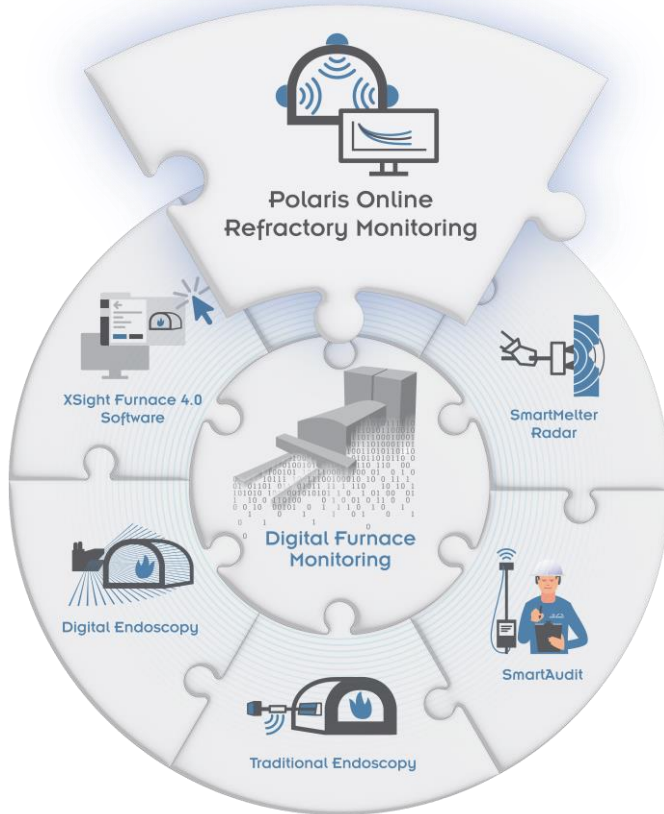
- With portable SmartMelter equipment.
- “Normal” sets for furnaces that are grounded. Only turn off boost for areas adjacent to electrodes or to follow plant safety.
- Highly insulated equipment for measuring ‘floating’ furnaces such as LCD furnaces while under power.

All-electric that could safely be measure under boost



Polaris™

Continuous Refractory Monitoring Sensors

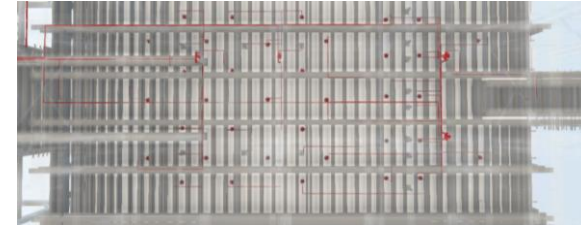


- Monitor high risk areas for early detection of glass penetration
- Understand the effect of operations on furnace life before it is too late

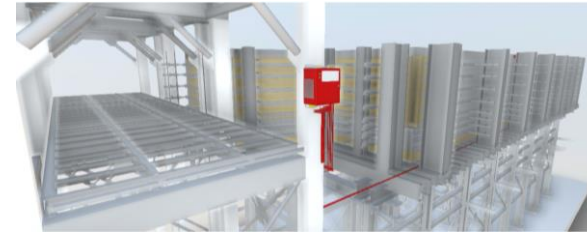
What is Polaris™ ?

- Continuous monitoring of refractory anywhere on the furnace: IoT sensors permanently installed on refractory
- Sensors operate at higher temperatures (1000C and higher) indefinitely
- Maintenance - Free
- Sensors can see a deeper range than SmartMelter sensors
- Can be installed anytime during the campaign
- Can be removed and reapplied across the furnace
- IP65 for furnace bottom monitoring

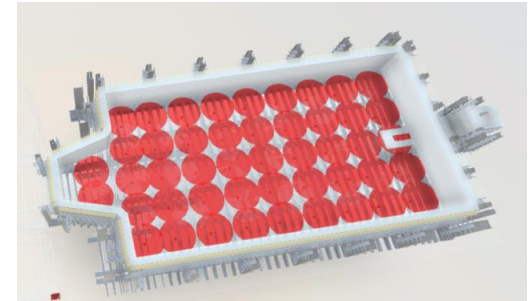
Sensor Network in Furnace Bottom



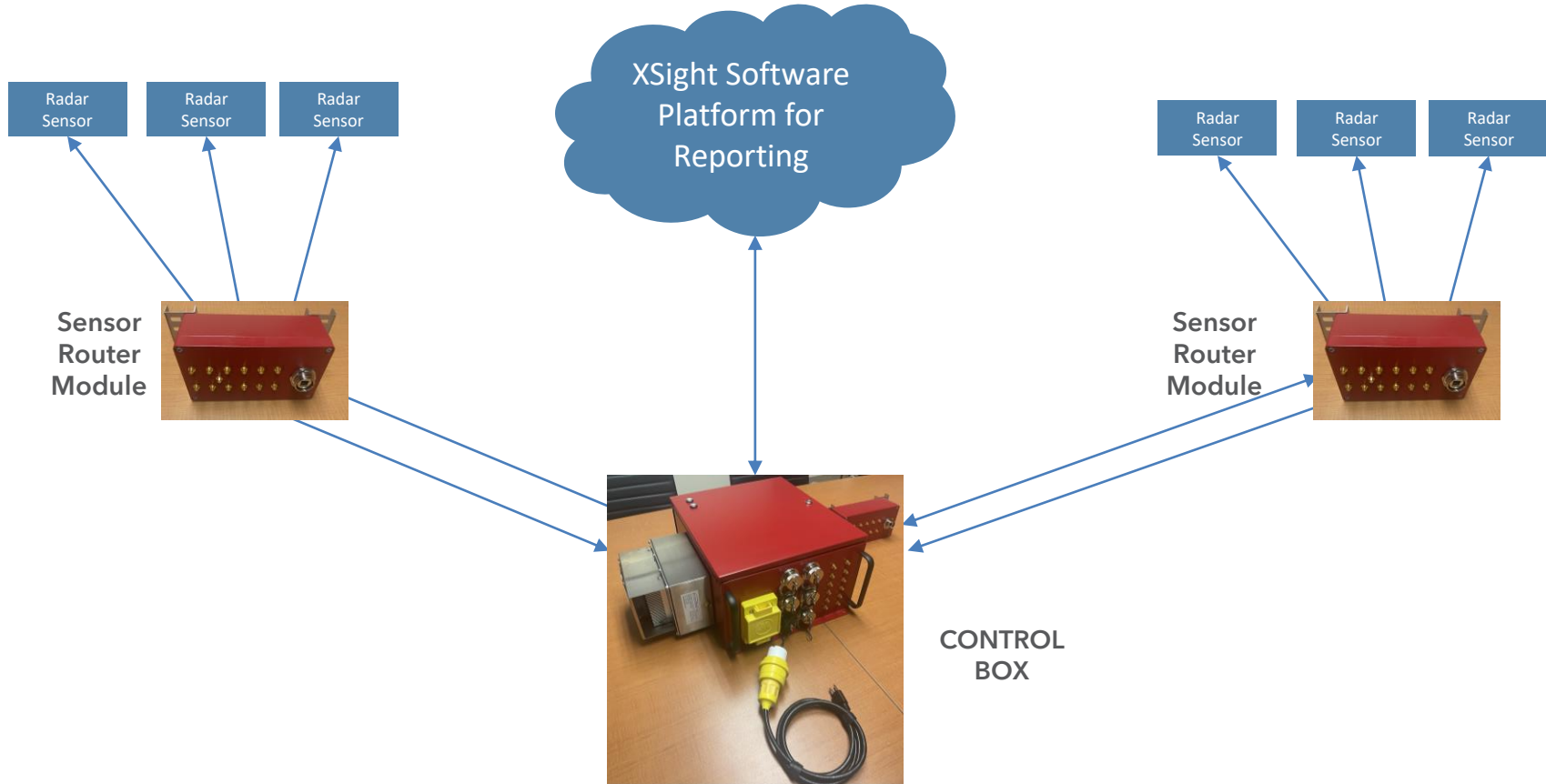
Control Box



Furnace Bottom Area Continuously Monitored



Polaris™ System Architecture

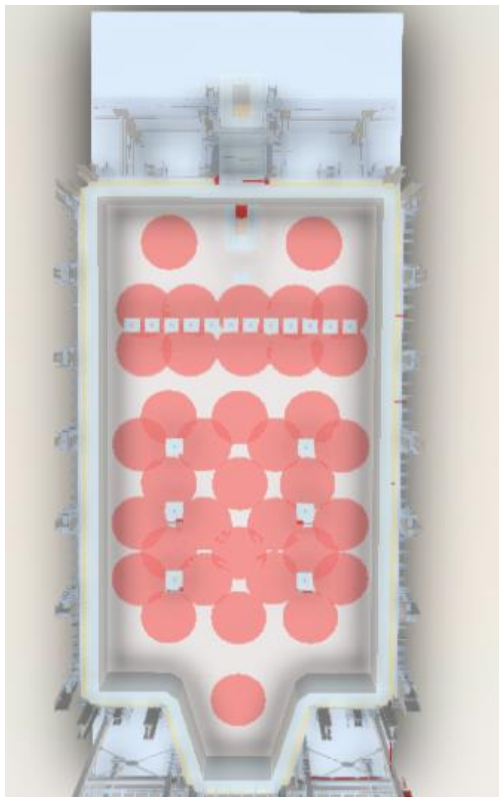


Polaris™ Sensor at Libbey Glass Furnace Throats

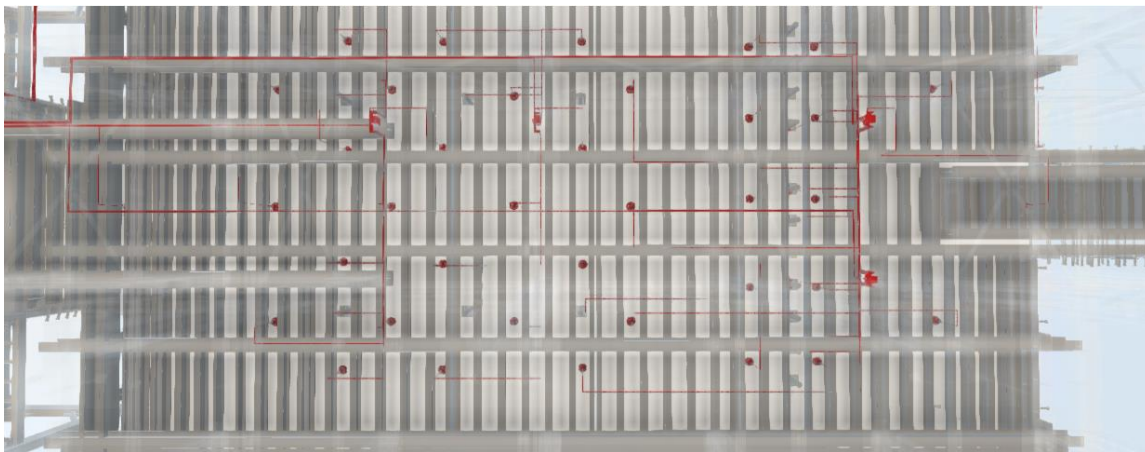


Furnace Bottom Electrode Area Monitoring

Continuous Coverage Area



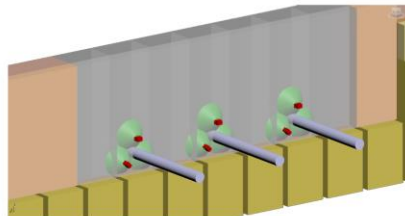
Polaris™ Sensor Network Around Electrode Blocks



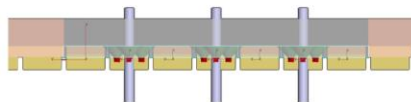
Case study boosted furnace 2023

- Management requiring furnace to operate 2 years longer than budgeted
- Increased electrode holder temperatures
- Polaris will alert if predefined thresholds are exceeded

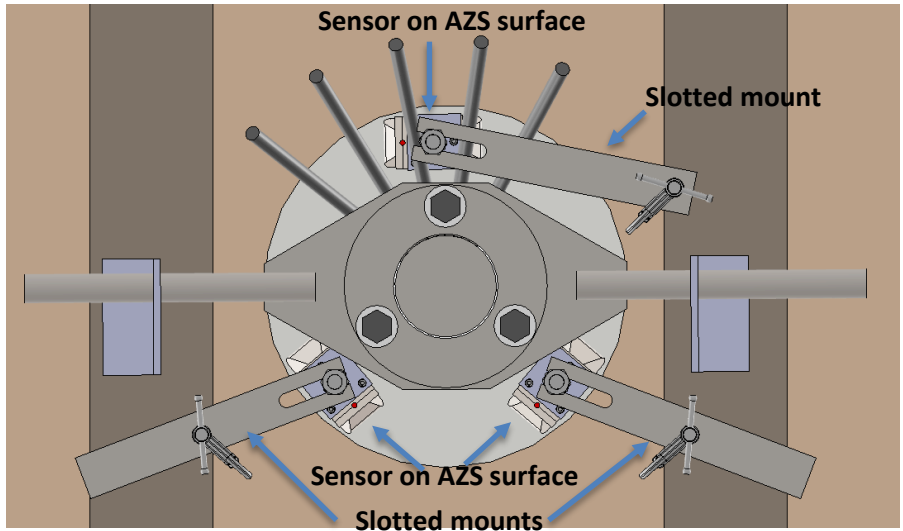
Sidewall Polaris Sensor Proposition



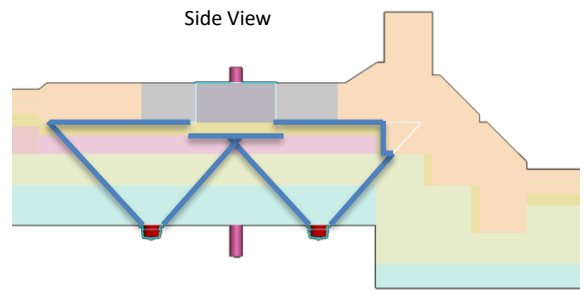
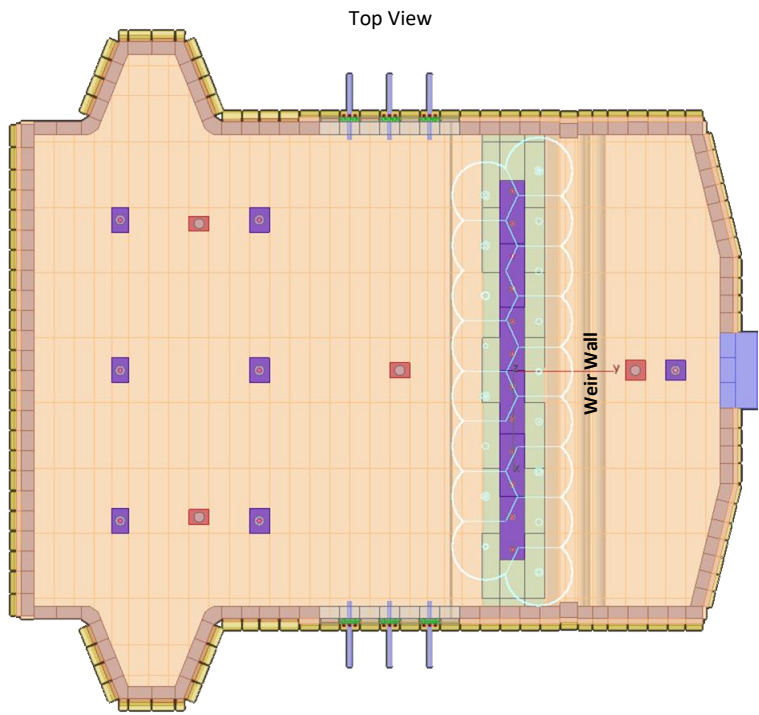
- Each set of three positioned optimally to cover surrounding area.



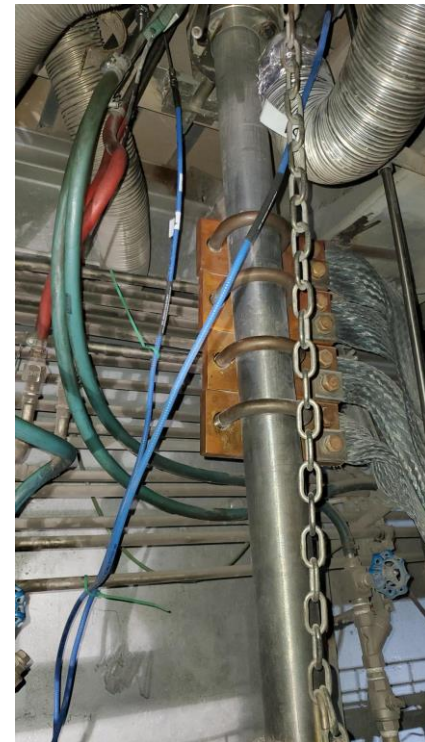
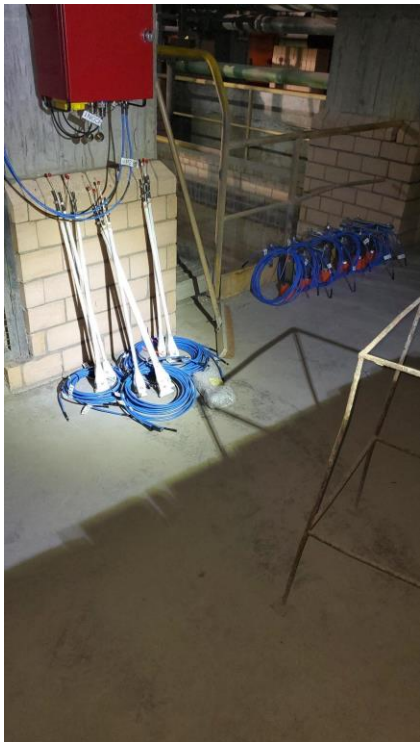
Electrode Monitoring System



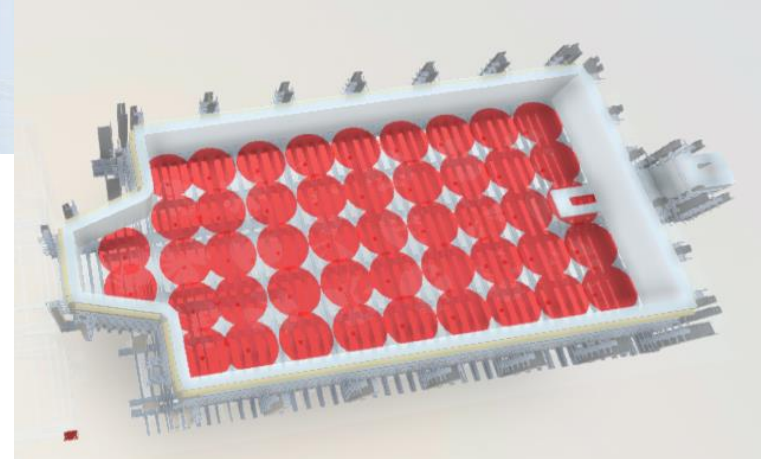
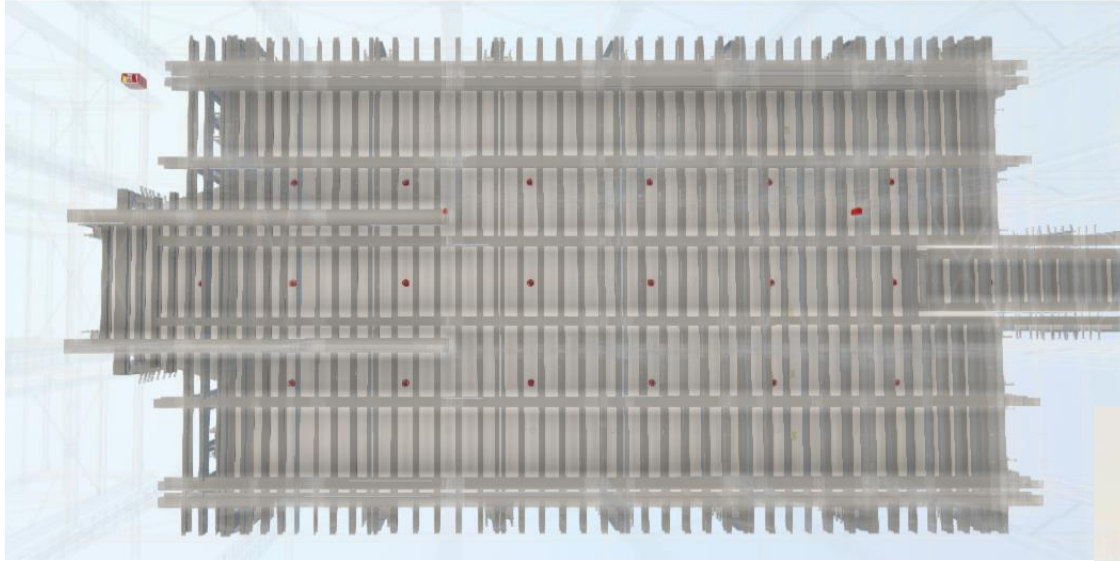
Electrode Monitoring System



Electrode Monitoring System Installation



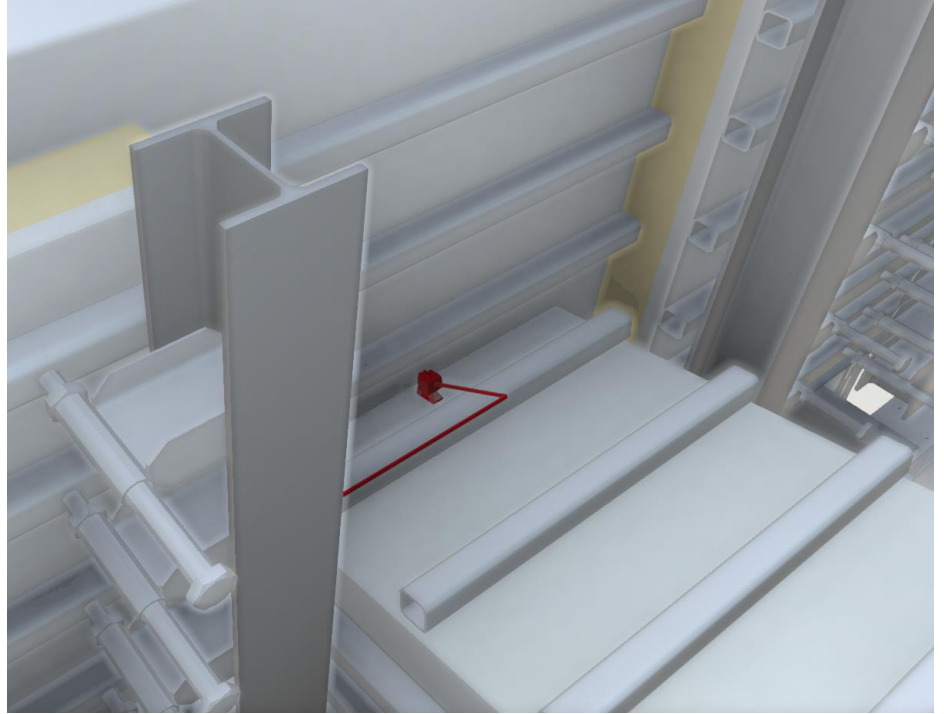
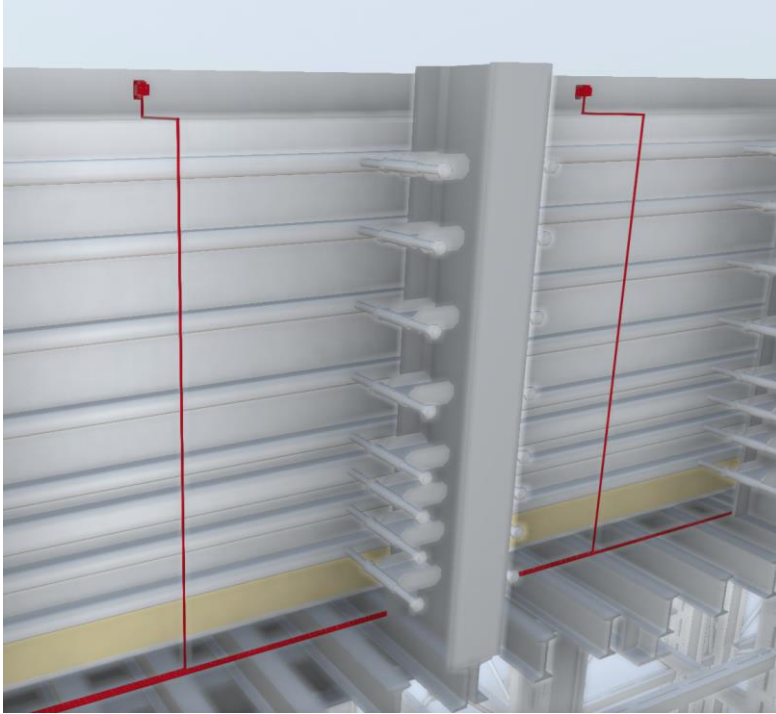
Furnace Bottom Monitoring with Polaris



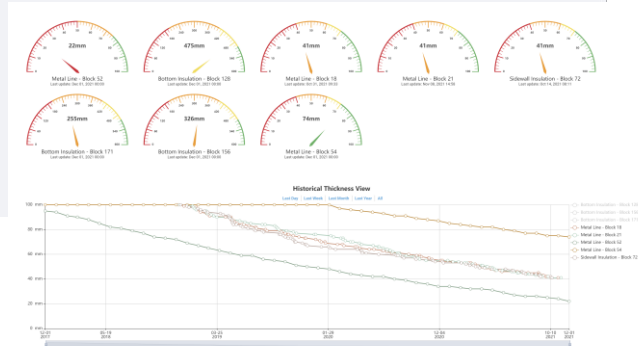
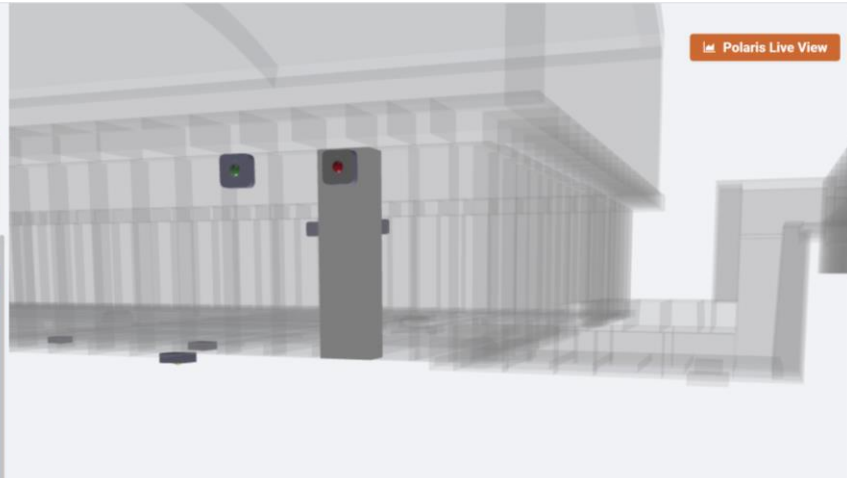
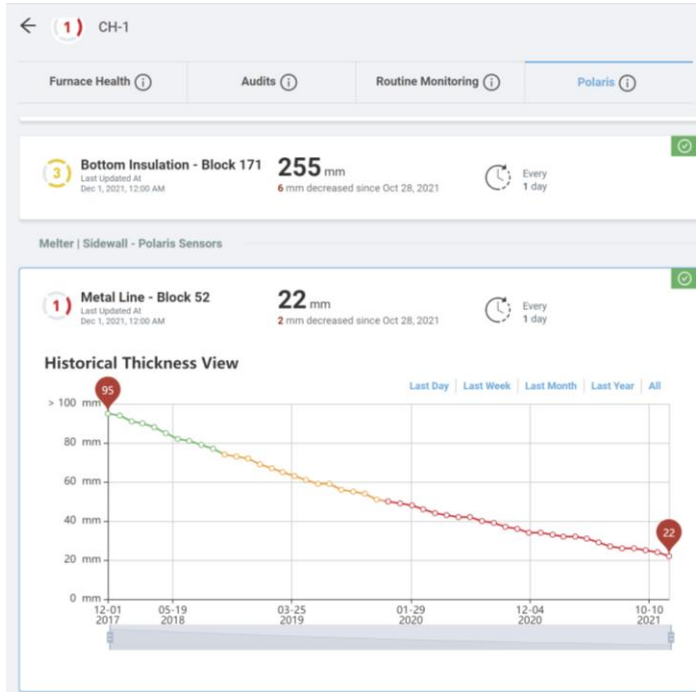
Polaris™ Bottom Installation



Furnace Sidewall and Throat Monitoring with Polaris



Polaris Software in XSight



Polaris™ Software



Chantilly
CH-3
No Launch Date Entered

69 %
1.9 yrs
2305 / 15000
15.8 %
10.1 yrs
Calculated by Target Rebuild Date

2.3k
Curr.Ac.Sp.Pull (ton/sqm)

3.6
urea.Sp.Op.Pull (mt/ton/sqm/day)

11.0
Op.Electric Ratio (%)

Passport Add Activity



Asset



My Tasks



User Management



Plant Management



PT Glass



Welcome, Yakup Bayram

Furnace Activities IoT Sensors Operations To-Do List

Bottom

48

Sidewall

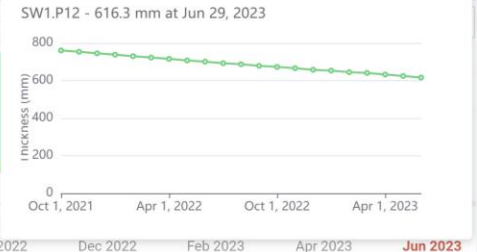
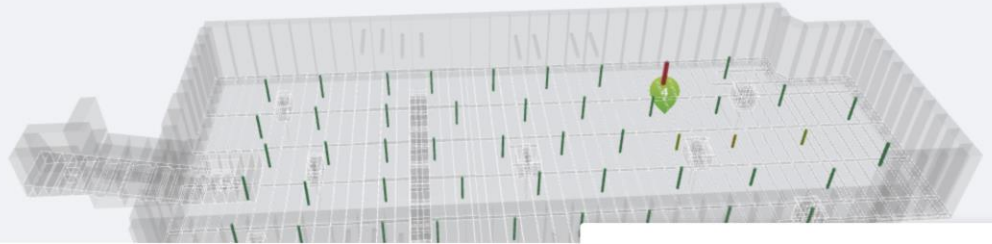
12

Show All Sections

Insulation

Filter

Risk Level	Sensor Name	Thickness
4	Block 17 - SW1.P1	Every 3 Hour 616 mm Jun 29, 2023
4	Block 19 - SW1.P2	Every 3 Hour 616 mm Jun 29, 2023
4	Block 55 - SW1.P3	Every 3 Hour 534 mm Jun 29, 2023
4	Block 56 - SW1.P4	Every 3 Hour 410 mm Jun 29, 2023
4	Block 57 - SW1.P5	Every 3 Hour 596 mm Jun 29, 2023
4	Block 84 - SW1.P6	Every 3 Hour 616 mm Jun 29, 2023
4	Block 90 - SW1.P7	Every 3 Hour 616 mm Jun 29, 2023
4	Block 100 - SW1.P8	Every 3 Hour 452 mm Jun 29, 2023



Polaris™ Software



Chantilly
CH-3
No Launch Date Entered

69 %
1.9 yrs
Calculated by Target Rebuild Date

2305 / 15000
15.8 %
10.1 yrs
Curr.Ac.Sp.Pull (ton/sqm)

3.6
3.9
urea.Sp.Op.Pull (mton/sqm/day)

11.0
19.0
Op.Electric Ratio (%)

Passport Add Activity

Furnace Activities IoT Sensors Operations To-Do List

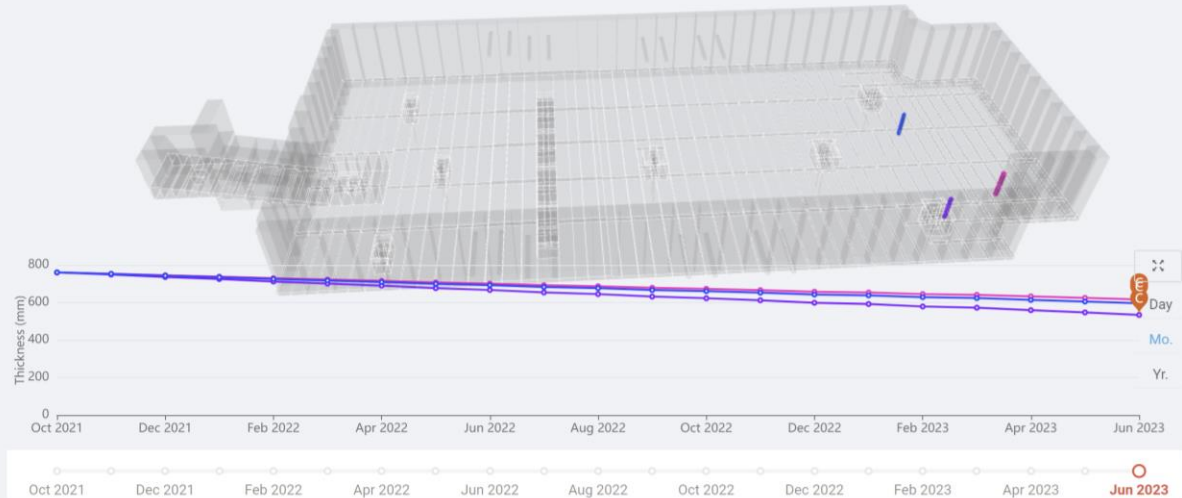
Bottom 48 Sidewall 12

Risk Level Sensor Name X Clear All Selection

4	Block 17 - SW1.P1	Every 3 Hour	616 mm Jun 29, 2023	☒
4	Block 19 - SW1.P2	Every 3 Hour	616 mm Jun 29, 2023	☐
4	Block 55 - SW1.P3	Every 3 Hour	534 mm Jun 29, 2023	☒
4	Block 56 - SW1.P4	Every 3 Hour	410 mm Jun 29, 2023	☐
4	Block 57 - SW1.P5	Every 3 Hour	596 mm Jun 29, 2023	☒
4	Block 84 - SW1.P6	Every 3 Hour	616 mm Jun 29, 2023	☐
4	Block 90 - SW1.P7	Every 3 Hour	616 mm Jun 29, 2023	☐
4	Block 100 - SW1.P8	Every 3 Hour	452 mm Jun 29, 2023	☐

Show All Sections
Show Insulation/Overcoat
Show Polaris Coverage

Insulation
Filter



HYDROGEN ASPECTS

Hydrogen Melting

- You will be “monitoring” an invisible flame
- Safety aspects (small molecule = leaks)
- Superstructure refractory selection
- Increased heat transfer to refractory walls
- Regenerators?
- What are the “unknowns”?

Digital Endoscopy™

Advanced Superstructure Inspection



- Uses laser technology
- Determines actual superstructure thickness and movement
- Performed while furnace is in operation

Digital Endoscopy

- Laser scanning through multiple peepholes
- Use of external reference points gives us depth
- Depth allows monitoring over time. (crown erosion, superstructure walls leaning)

Digital Endoscopy- Patent Pending



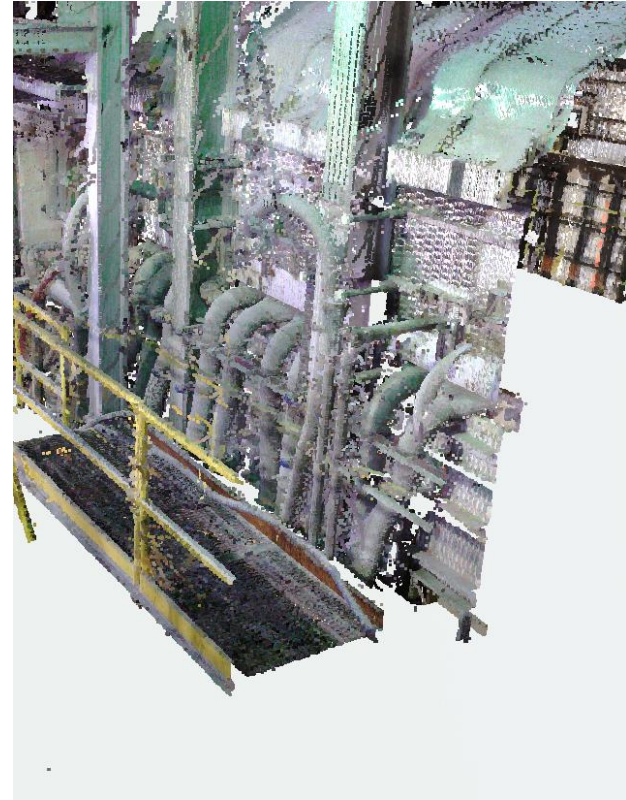
- **Sensor capabilities**

- 500,000 [points/second] scanning speeds
- 3 [millimeter] sensor accuracy
- < 1 [minute] scanning times
- No data issues scanning hot glass furnace surfaces

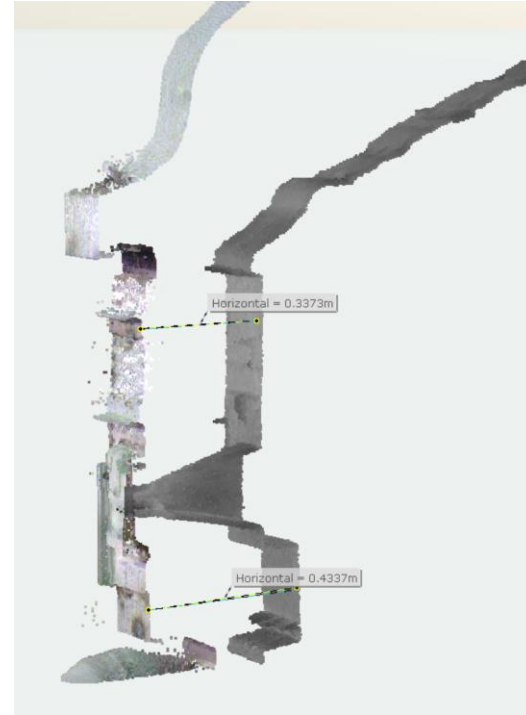
Digital Endoscopy™



Digital Endoscopy™ - Patent Pending



Digital Endoscopy



Hybrid melting???

- High Boost – Natural Gas?
- High Boost – H₂?
- High Boost H₂/NG?
- Boost rates that widely vary 20-80% with above fuels?
- Low/no boost H₂/NG?
- Above combinations with bio-fuel?
- Above combinations using O₂?

NG = Natural Gas

My monitoring assumption is high boost

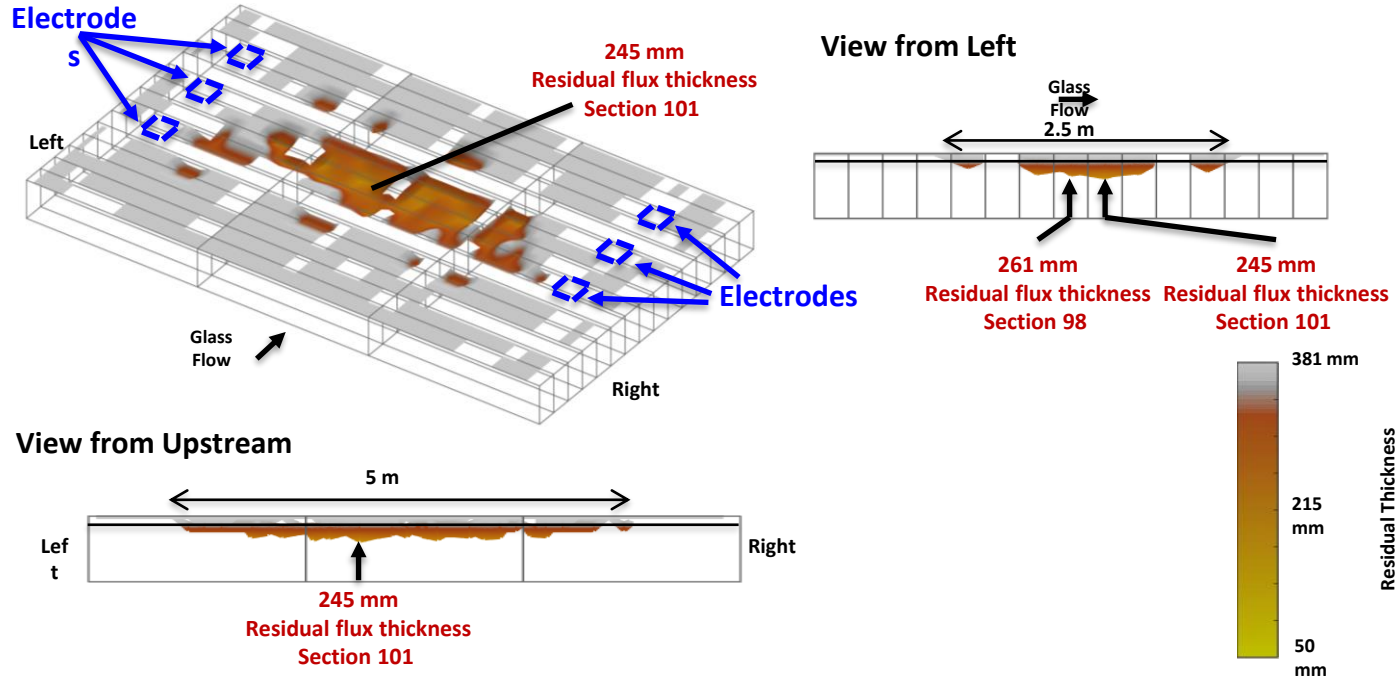
- Refractory monitoring practices as before.
- SmartMelter portable equipment
- Polaris online monitoring (high wear and difficult/dangerous to access areas)
- Digital/traditional endoscopy

CASE STUDY: HIGH PCR CULLET USAGE

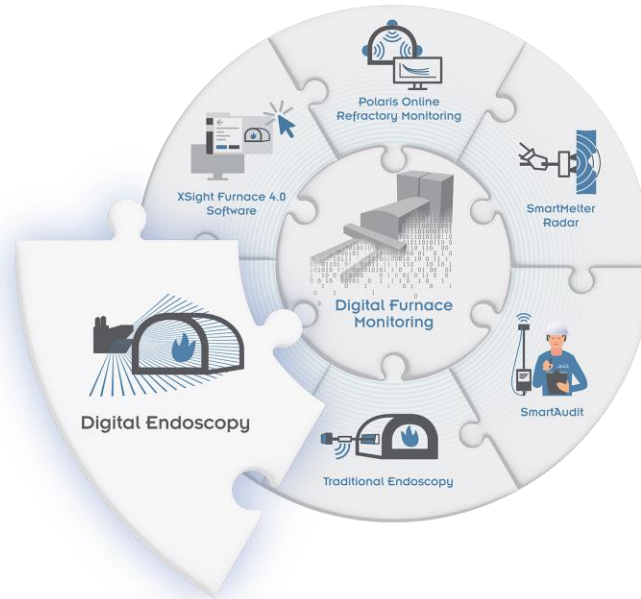
Case study high PCR cullet use

Results

- Area of concern discovered on downstream area before throat. Minimum residual thickness of the cast flux blocks (originally 305 mm) is 245 mm at section 101. **Affected area is 5 meters x 2.5 meters in size.**
- Gray areas are of full thickness to the bonded AZS.
- White areas are not measured.



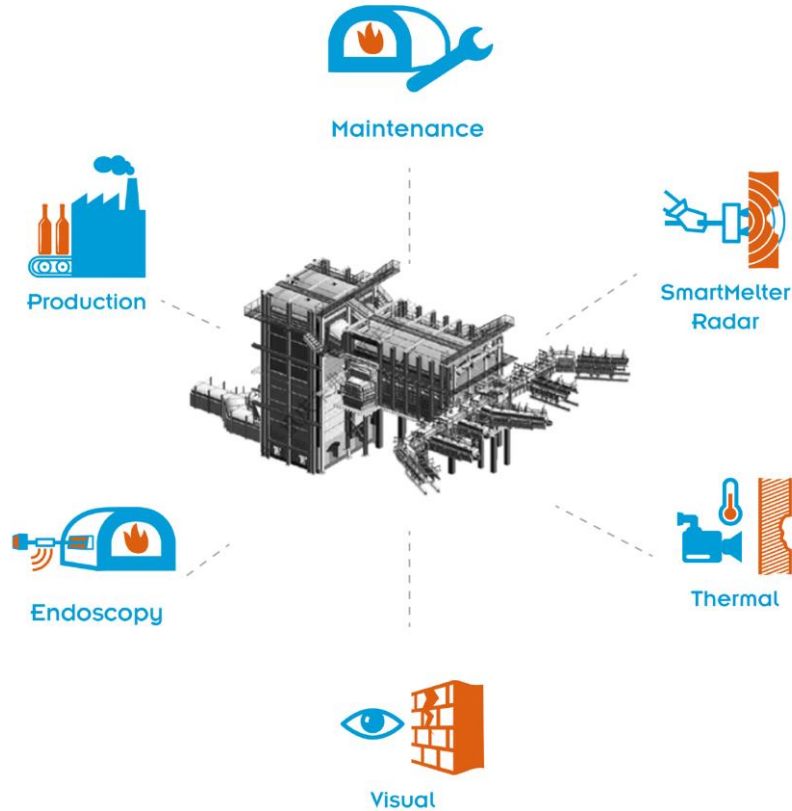
XSight



Tieing it all together with XSight

- XSight is a refractory maintenance platform
- Multi-plant, Multi-furnace, Multi-user, Multi-language
- XSight can incorporate KPI's
- All SmartMelter results are published on this platform
- 3D and interactive
- Polaris live data is displayed
- Digital and traditional endoscopy are stored here.
- Thermal surveys
- Observations

XSight: Digital Furnace Platform for Reliable Production



XSight: Furnace 4.0 Platform

Furnace Health Management Module



Sensor Agnostic Digital Data Integration



Asset Reliability Management



Asset-Specific Monitoring Program



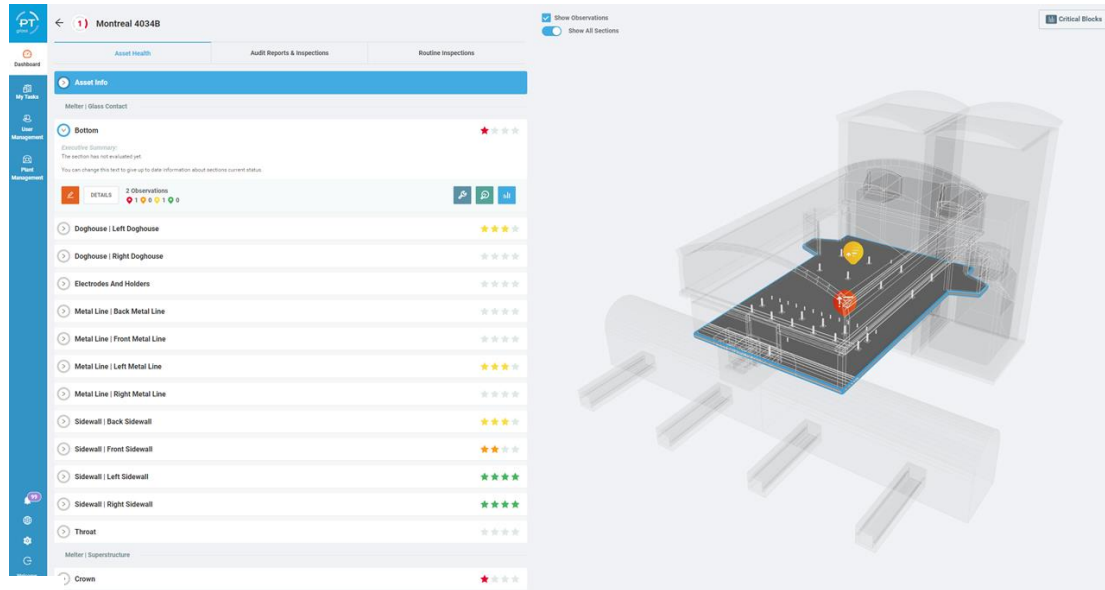
Asset Management across Multiple Plants



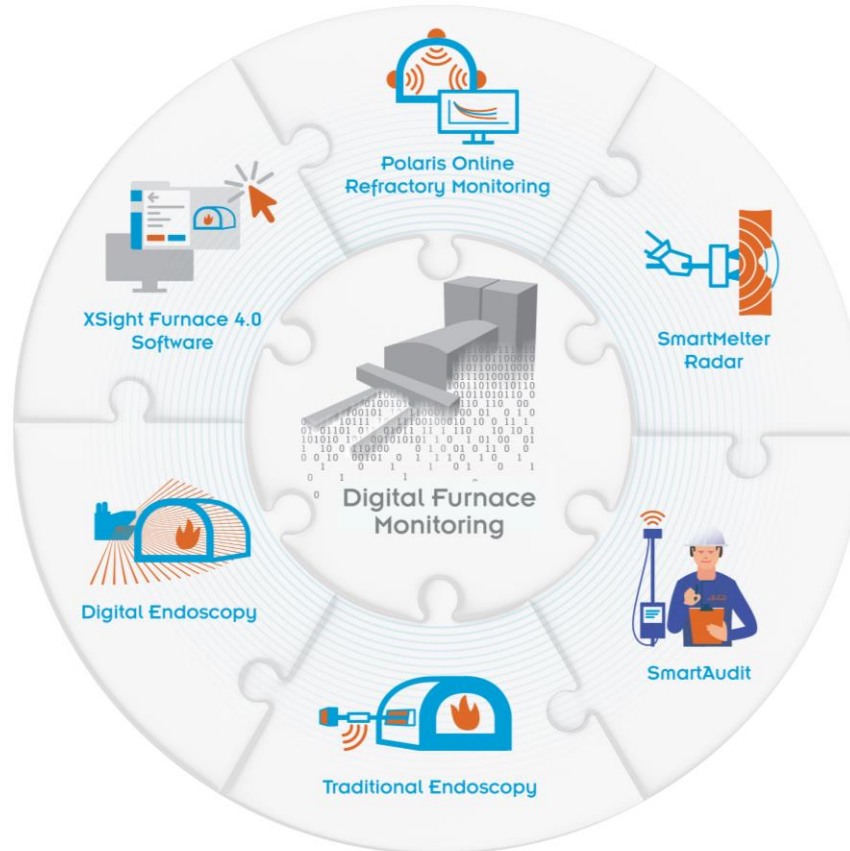
User/Plant Management



Private Cloud Integration for Data-Sensitive Customers



Digital Furnace Monitoring



DFM

- DFM is using the best tools available to monitor your furnace
- DFM is not a predefined product or service
- We define DFM together with customers for them to meet their goals

ENABLE

Summary

- New melting technologies will bring new challenges.
- Through existing tools as well as ones in development, we will help you manage these still unknown challenges.

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