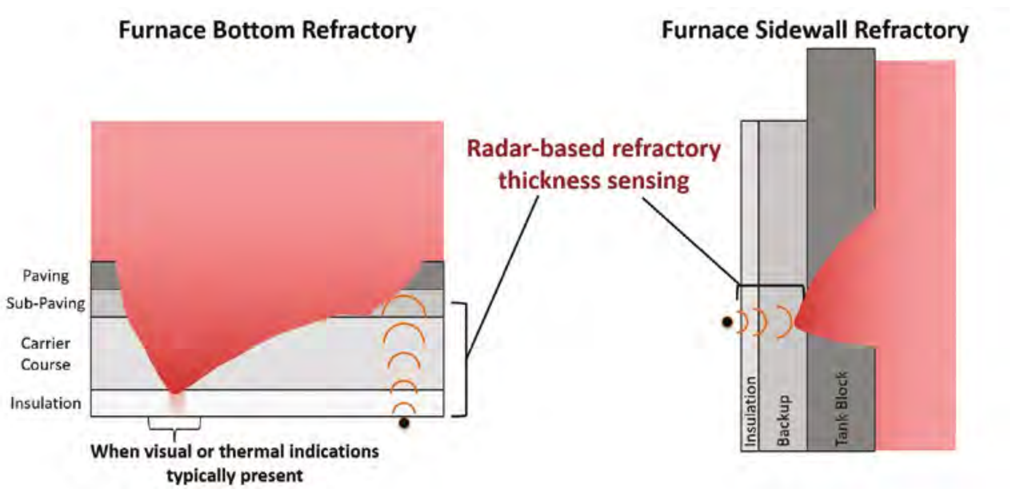
Responding to emergencies two years in advance

The introduction of radar-based refractory inspection in 2017 brought new insight into the rate of wear of the inner insulation and protection layers. Data from nearly 1 million measurements on over 300 furnaces shows that once glass infiltration begins, a furnace can continue to operate much longer than anticipated. Alex Ruege and Jon Wechsel from PaneraTech explain what they have learned.

Until recently, quantifying how long backup refractories will last before failing on operational furnaces has been a challenge for glass manufacturers. The industry has relied on techniques such as thermal sensors, test drilling, visual inspection and other indirect methods such as historical data. These techniques give an incomplete picture of the integrity of the refractories. Making matters worse, thermal or visual sensing may only respond to glass infiltration that has already compromised the containment to a point where urgent decisions must be made. The original problem that has caused the critical situation may have begun years earlier, but given the inspection techniques at the time, operators may assume that early glass penetration into insulation may lead to a major leak within days.

Our experience monitoring over 300 glass furnaces with SmartMelter radar over almost four years has shown us that the original assumptions about the rate of wear of materials like firebricks, flux and bonded AZS were not accurate. Through SmartMelter radar mappings, once glass was discovered to have penetrated bottom and sidewall materials, continued operation was possible for much longer than originally anticipated. Guided by these radar mapping results, in some cases these furnaces have lasted two years without failing.

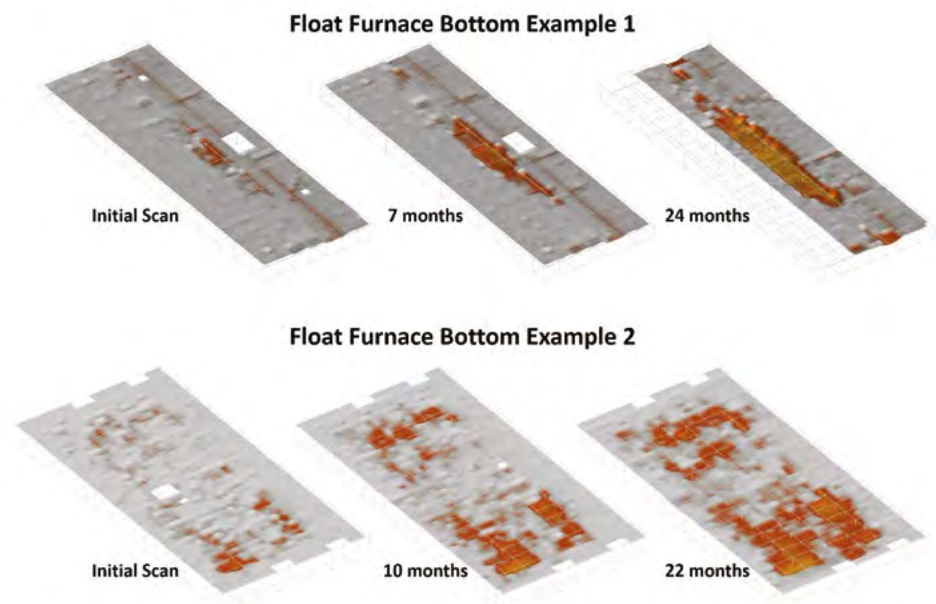


General furnace bottom and sidewall refractory configuration.

How SmartMelter monitors refractory wear

Using radar mapping, a three-dimensional map of the internal glass penetration inside of the furnace materials can be constructed. This is done by sending extremely low power radar signals into the materials at different positions and measuring those echoes that come back from the glass infiltration. Regular radar mapping will provide a timeline of information regarding the spread and depth of refractory wear.

When considering furnace bottoms and sidewall backup designs, many furnaces have a similar construction. On bottoms, the glass-contact pavers are typically followed by sub-paving layers which may consist of a variety of corrosion-resistant refractories such as zircons, castables, rams, and bonded AZS materials. Below these, the carrier courses are composed of alumina-silica fireclay materials such as superduty firebrick or sillimanite. Under the carrier courses are the highly insulating materials which are meant to thermally insulate the furnace. Because of the highly insulating nature of these materials, the outer surface temperature will increase by a measurable degree only as glass penetration makes its way into the weakest outer layers. At this point, very little time remains before glass would make its way through those insulating layers. In contrast, radar-based refractory thickness sensing ▸



Radar mapping of showing the progression of glass penetration into a float furnace bottom.

will reach much deeper into the furnace bottom and well beyond the outer insulation materials, providing extended time to mitigate the issue to best fit the manufacturer's schedule and plans.

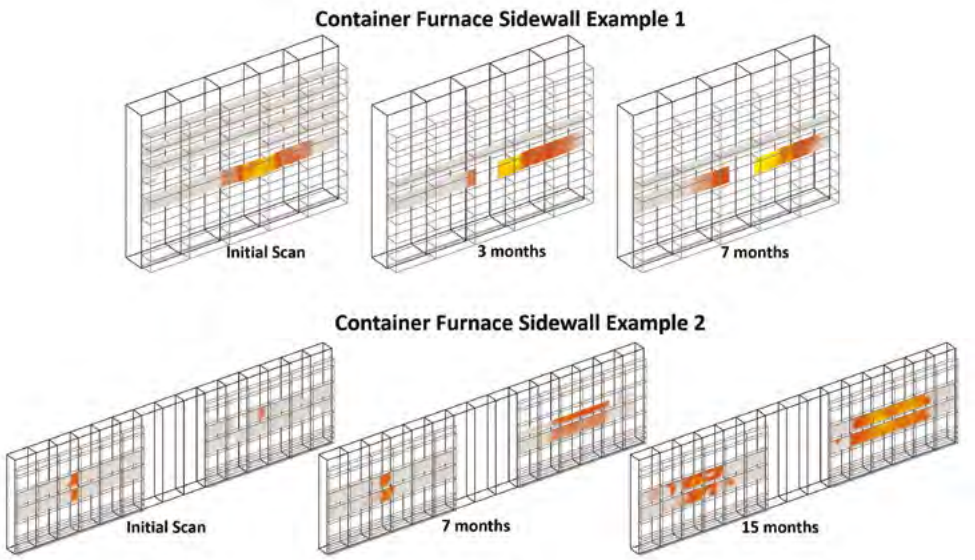
Relying on temperature alone

When manufacturers rely on temperature, they are forced to make hasty and often costly decisions. PaneraTech performed radar mapping on a container furnace where hotspots had already been observed on the bottom. Radar mapping found that 85% of the total bottom thickness was gone with glass infiltration into the outer layers. Based on the data collected, immediate repair was recommended. However, the plant had commitments to fill for six months. Operation continued for four months before a bottom leak occurred. As we can learn from this experience, temperature indications given on the furnace bottom provided very little time to react. Because of the nature of radar, which can reach much more deeply into the materials, glass penetration can be found at a much earlier stage.

Benefits of early detection

Example 1: Float furnace bottom repaired two years after glass detected

The first mapping done on this bottom indicated wear into the outer clay flux. After two years, the thickness reduced by 120mm at the worst locations on the bottom. However, we observed that the affected area spread laterally by seven times of the original area over the course of those two years. Water and air cooling was applied on the bottom surface and was gradually increased and changed as guided by the radar mappings. These mappings allowed the presence of glass infiltration to be known by the manufacturer and proper maintenance plans were set in place well in advance of the needed repair, which occurred two years after the initial mapping where glass infiltration was discovered.



Radar mapping of glass penetration progression into a container furnace sidewall.

Example 2: Float furnace bottom repaired 22 months after glass detected

As in the first example, early-stage glass penetration was found in the initial radar mapping in this float furnace's clay flux bottom layer. This glass penetration also spread significantly over a period of nearly two years. However, the thinnest area only lost 50mm of material. Air cooling was applied on the bottom surface after the initial radar mappings. Once again, the furnace was safely shut down and repaired 22 months after the initial mapping.

Example 3: Container furnace sidewall repaired 7 months after glass detected

On a container furnace sidewall, which was composed of bonded AZS, firebrick and insulation board, initial radar mappings of the area showed deep infiltration into the bonded AZS layers in front of the outer firebrick layer. Over a period of seven months, only 8mm of the bonded AZS was lost at the worst locations. The outer insulation board was removed, and cooling was applied in these concern areas. A sidewall repair of the area took place seven months after the initial discovery and furnace operations continued.

Example 4: Container furnace sidewall repaired 15 months after glass detected

On a similar container furnace sidewall, the first radar mapping of a sidewall area discovered the early stages of glass infiltration into the bonded AZS layer. After 15 months, the worst-case location only lost 10mm of the bonded AZS. However, the affected area increased dramatically, spreading from only two tank blocks to 10 blocks. The outer firebrick layer was removed, and a significant amount of air cooling was applied to the bonded surface. Soon after the last radar mapping, the furnace was safely shut down and repaired.

New data supports better decisions

Given this new knowledge, we now have a better understanding of just how well specific refractory materials perform within sidewall and bottom backup packages under many different operating conditions in the glass manufacturing industry. Identifying when and to what extent glass makes its way into the backup materials provides a data-driven assessment of the health of the asset and gives a manufacturer the confidence to either continue to operate safely or make the best-informed repair decision. ●

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