Cutting CO_2 emissions with SEFPRO electric furnace solutions

XeBOOST™: HELPING GLASSMAKERS CUT EMISSIONS IN ELECTRICALLY-BOOSTED FURNACES

Every year, more than 200 million tons of container, flat and specialty glasses are being produced to serve the needs of the beverage, food, construction and pharmaceutical industries among many others. Historically, glass production has predominantly relied on furnace designs with minimal electrical boosting, usually accounting for less than 10 percent of the furnace's total energy input. Significant reductions in CO2 emissions can be achieved through a considerable increase in electric boosting using renewable energy sources, which also improves furnace thermal efficiency and reduces GHG emissions. The next generation of furnaces, currently in design phase or undergoing construction, is already leaning towards advanced configurations such as super boosted (30-40 percent electric), hybrid (over 50 percent electric), or fully electric melting. These next generation furnace technologies face new challenges, including higher glass temperatures and increased insulation requirements. Additionally, there is a necessity to manage higher electrical current densities. This leads to faster corrosion of the refractories and higher risk of electric boosting failures - ultimately resulting in an overall shorter furnace lifespan.

CONSEQUENCES OF HIGH ELECTRICAL BOOSTING ON GLASS FURNACES

The implementation of enhanced boosting capabilities in the furnace bottom will require thicker paving tiles and the use of more durable refractory materials with tailored electrical properties to ensure reliable operation and a cost-effective furnace lifespan. The expected glass temperature increases of more than 60°C (Figure 1), will more than double the direct corrosion rate of refractories. With higher glass temperature, the furnace bottom can also experience glass infiltration, which could lead to the uncontrollable phenomenon of upward drilling beneath the paving tiles. The risk of glass infiltration is also augmented by the increased number of joints between tiles due to the higher number of electrodes in the paving.

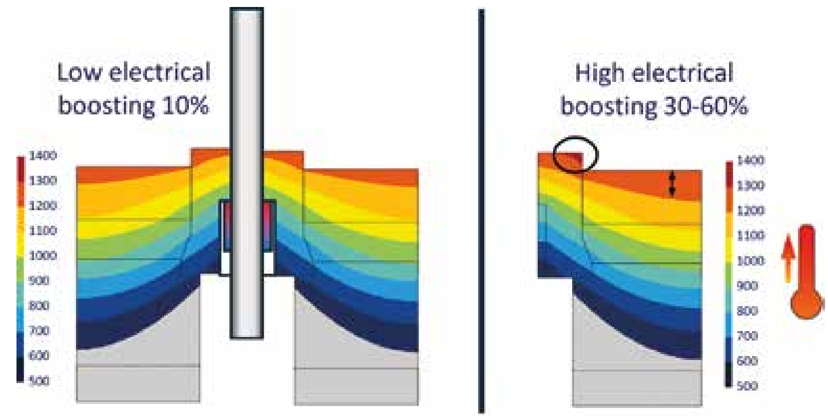

Fig 1 - Bottom paving temperature typically rises by +50°C / +60°C

Advances such as SEFPRO XeBOOST™ refractories are reshaping electric-boosted glass melting by enabling higher reliability, reduced CO_2 emissions and greater electrification. With furnaces transitioning toward hybrid and super-boosted designs, durable high-resistivity materials have become essential to protect equipment, extend lifespan and sustain decarbonisation goals.

Additionally, the increased glass temperature and velocities in highly boosted furnaces are expected to accelerate the corrosion of the sidewalls. Recent designs for hybrid furnaces feature soldier blocks with increased thickness from 250mm to 300mm and are made with AZS exhibiting higher zirconia grades.

CHALLENGES ASSOCIATED WITH ELECTRODE BLOCKS

With at least 3 times more electrodes implemented in hybrid melters compared to conventional furnaces, electrode blocks are now subjected to higher current density and increased glass velocity. As the soda contained in the glass diffuses deeply into the refractory over the furnace lifetime, the electrical resistivity of AZS refractories dramatically decreases from 150 ohm.cm down to ~20 ohm.cm (Figure 3). The refractory corrosion resistance also declines, accelerating the wear of the top of the electrode block. This phenomenon is amplified by higher temperatures and the glass convection currents.

When the electrical resistivity of the refractory material gets close to the electrical resistivity of melted glass, current can be deviated through the refractory and eventually could lead to shorts-circuits (also called floor tracking). This ultimately could lead to the melting and failure of the electrode block. Consequences could be dramatic for the glass furnace: power and pull rate limitations, potential glass

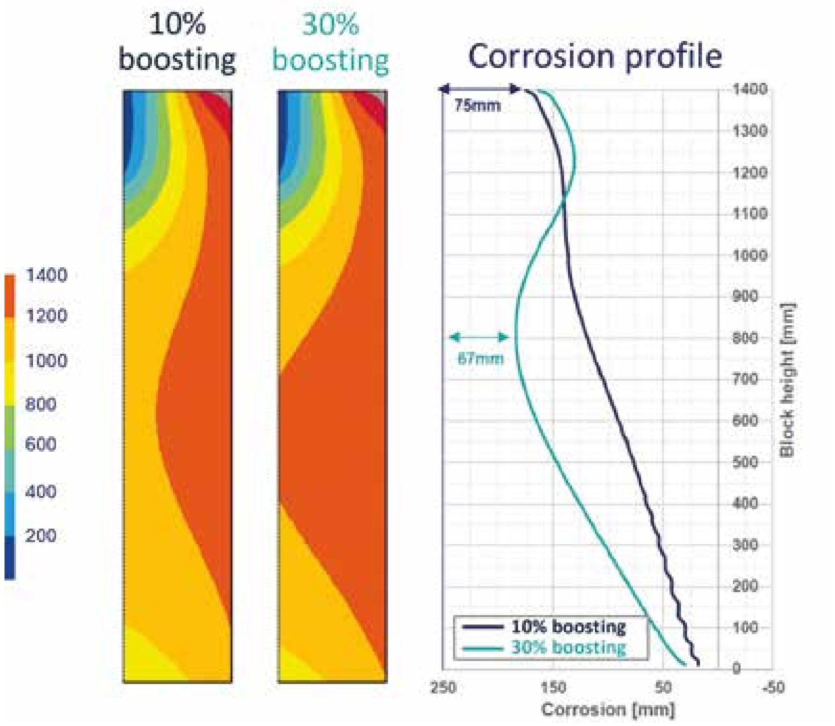

Fig 2 - Effect of high boosting on sidewall temperature

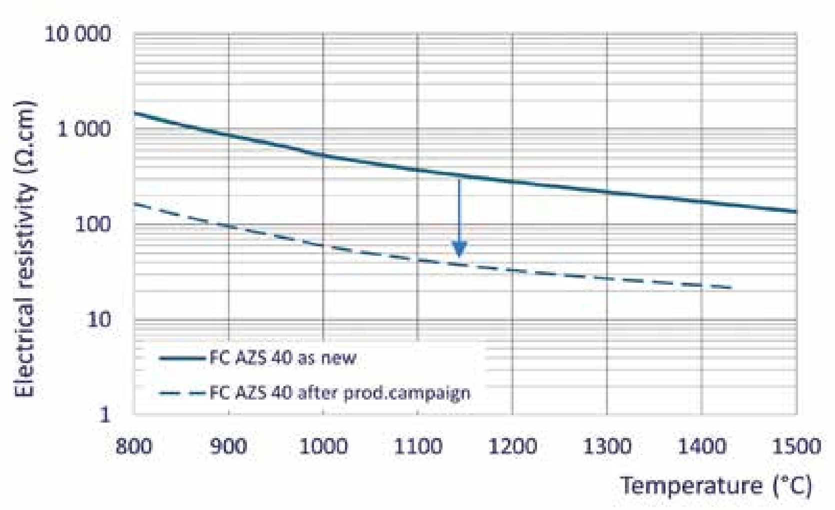

Fig 3 - Refractory electrical resistivity drop after campaign in Sodalime glass leaks or glass defects. Any failure of an electrode block would require an increase in fossil fuel consumption to maintain the energy input, counteracting the initial goal of decarbonisation.

HIGH ELECTRICAL RESISTIVITY

Decades ago, isopressed zircon bricks and resistive fused cast High Zirconia (HZ) were the only materials known for their high electrical resistivity and were predominantly used for display glasses, reinforcement glasses, and specialty glasses. However, isopressed zircon cannot be used for sodalime glass because of its dissociation ($ZrSiO_4$ ZrO_2 + SiO_2) at approximately 1,400°C. Even though High Zirconia (HZ) could be a high-performing paving solution, the associated CAPEX difference is considerable, and their use is limited to niche applications. Engineered by SEFPRO as part of the AZS refractory family, XeBOOST™ refractory aims to achieve higher reliability and safer operation. XeBOOST™ solution tackles the electrical boosting challenges mentioned earlier by providing three times greater electrical resistivity (Figure 4) than a standard AZS containing 40 percent ZrO_2.

Even after soda infiltration, the electrical resistivity of XeBOOST™ technology remains significantly higher than of AZS40. Figure 4 also evidences that the electrical resistivity of XeBOOST™ material remains at least one order of magnitude higher than that of sodalime and borosilicate glasses, suggesting that XeBOOST™ innovation can significantly strengthen the reliability of furnace boosting systems.

IMPROVED CORROSION RESISTANCE

With 46 percent of Zirconia, XeBOOST™ refractory is setting a new AZS standard for tank side wall blocks, usually made of AZS fused cast with a 36 percent or 41 percent ranking of Zirconia.

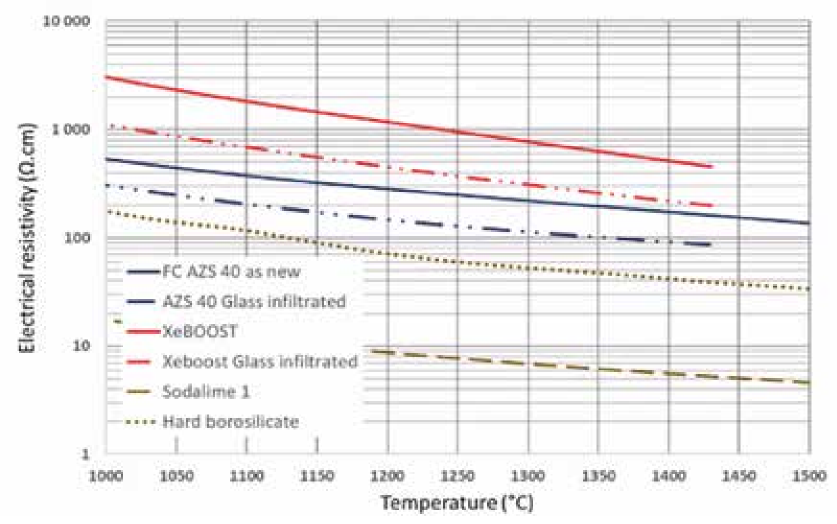

Fig 4 - Electrical resistivity drop after glass infiltration test

Laboratory-based qualification tests performed on a wide sample panel are predicting a total MGR corrosion resistance improvement of up to 15 percent compared to AZS 40 (Figure 5).

Furthermore, MGR dynamic corrosion tests are evidencing a significant improvement in corrosion at the glass line (Figure 6), by +20 percent.

SEFPRO developed a dedicated pilot glass furnace able to replicate melting conditions close to the ones in industrial glass furnaces. During the test, this furnace was powered by electrodes with electrical input varying from 15 to 20kW and voltage up to 200 V. It features bottom electrodes embedded in refractory blocks, allowing the evaluation of corrosion not only for the electrode blocks but also for the sidewalls. The furnace was tested over a two-month period, achieving an average glass temperature of 1,420°C, with peaks at 1480°C to replicate the severe conditions of high boosting. This pilot setup is able to evaluate up to three materials simultaneously for both locations (bottom paving and sidewalls). Post-mortem anal-

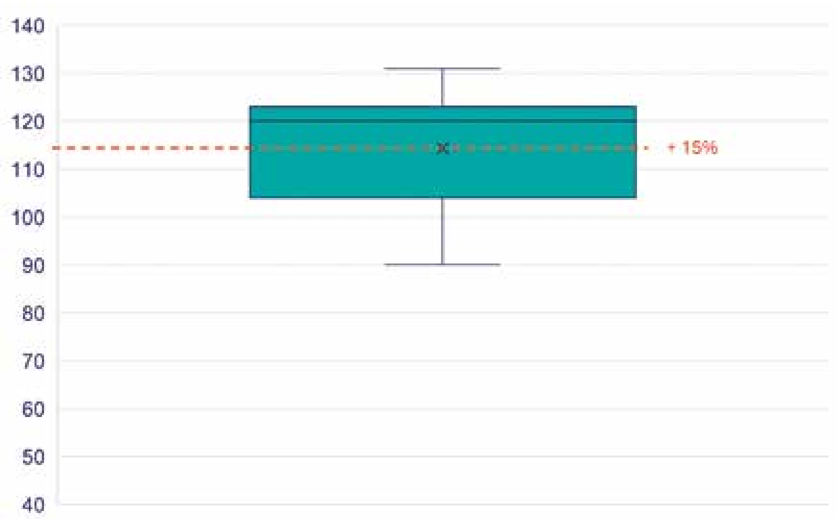

Fig 5 - Total corrosion index vs ER 1711 at 1500°C

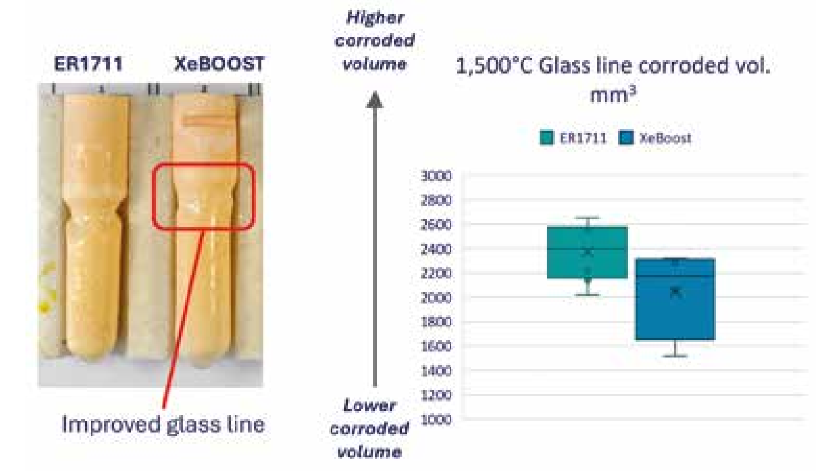

Fig 6 - MGR - Glass line corroded volume © SEFPRO, 2025. All rights reserved.

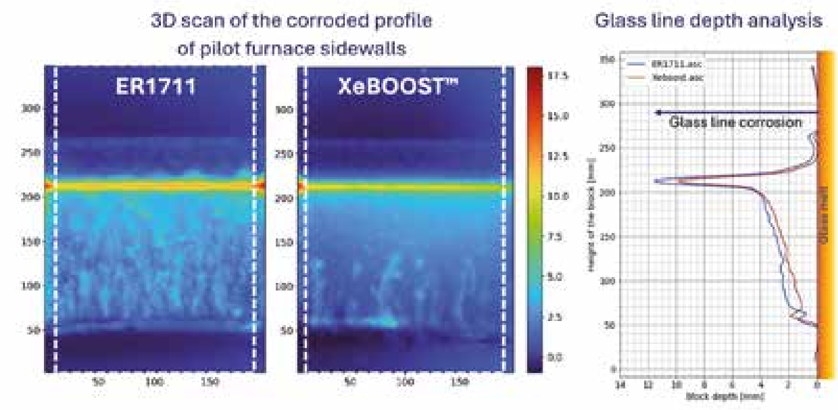

Fig 7 - Pilot glass furnace test © SEFPRO, 2025. All rights reserved.

yses and 3D scans confirmed that the glass line corrosion resistance of XeBOOST™ solution exceeds that of AZS 40 by 20 percent, resulting in enhanced performance for XeBOOST™ side wall blocks (Figure 7).

XeBOOST™, A PATENTED AZS MATERIAL FOR FURNACES WITH HIGH ELECTRICAL BOOSTING

XeBOOST™, a groundbreaking AZS refractory, is establishing a new standard, particularly under the demanding conditions expected in super boosted or hybrid soda-lime glass melting furnaces. Its exceptional properties, including high electrical resistivity and the highest corrosion resistance among commercial AZS refractories, make it an optimal choice for addressing challenges associated with increased glass temperatures and high electrical densities. Extensive laboratory qualification tests indicate a potential improvement in total corrosion resistance of up to 15 percent compared to AZS 40, along with a notable 20 percent improvement in glass line performance. As the industry shifts towards sustainability and reduced emissions, glass industry engineering teams should prioritise the adoption of advanced materials such as XeBOOST™ material to improve furnace reliability, facilitate higher electrification levels, and give sidewalls higher corrosion resistance.

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