When, almost 40 years ago, it was clear that a particular refractory lining niche, too large to be ignored, was still an orphan of a specific and optimized application, all major fused-cast manufacturers and glassmakers have been looking for a solution.

Among the primary bottlenecks in the glass contact refractory lining, throats have been (and still generally are) a critical weak point: it is enough thinking that for a typical modern furnace producing 300 tpd for a campaign of 10 years, more than 1 million tons of hot glass is transiting at a relatively high speed in a throat with very few square meters of glass contact surface.

The traditional blocks lining up of throats in soda-lime glass smelters has been based on fused cast high-zirconia AZS (41%) blocks. This application was fairly balanced with the application of low-zirconia AZS (32%) in the sidewalls and pavers, when the average furnace life was less than 8 years and the specific pull generally less than 2 tpd/sgm.

But, with the intensive application of electrical boosting, the improved furnace design, and the utilization of high-zirconia AZS (41%) fused cast blocks for the whole sidewalls, the campaign life has been exceeding 10 years, with specific pulls of more than 2.5 tpd/sgm. Under these boosted conditions (and other details like glass temperature), all seriously increasing the corrosive stress of throat materials, what has been done to balance the life of throats?

Unfortunately, there was (and is) no univocal response to this understandable exigency. Throats cooling by means of conveyed air or water cassettes is effective to reduce risks of leakage when the residual thickness of throat blocks is minimal but, in most cases, overcoating (some time multiple overcoatings) has been a common practice to extend the throat life, compromising progressively the throat efficiency, since the glass intake point, when abusing of throat overcoating moves up too close to surface glass, bringing more polluted glass to the working end and therefore worsening the glass quality going toward end of campaign.

The chrome move
A first effective solution to this problem has been installing chrome bearing blocks in the critical positions, like inlet beam and sleepers, covers. It was about fused-cast chrome-doped AZS or alumina-chrome and, more recently, the most effective isostatically pressed sinter chrome blocks. All these materials, at different degrees, share the advantage of not only have strongly improved corrosion resistance, but also maintaining the throat profile nicely unchanged and therefore keeping the throat efficiency for a much longer campaign life.

Unfortunately, this great solution has one single but serious condition that indicates the inadvisability in a particular application niche. It is about glass discoloration due to traces of chrome in the produced glass, when dealing with extra-clear white glass and particularly when producing high thickness items. It was the case of automotive lighting glass (now generally replaced by plastics) and it is the case of high quality tableware, decorative objects, white borosilicate tubing for medical devices and some more.

Here we are, with the significant niche, orphan of a specific acceptable application. Increasing the amount of zirconia in AZS fused cast, above the typical 41%, has proven to be ineffective in terms of corrosion resistance, since already at 41% the amount of corundum-baddeleyite pseudo eutectic is at a maximum and any further addition of zirconia is only increasing the presence of free Baddeleyite microcrystals surrounded by glassy phase. These crystals are not significantly contributing to the corrosion resistance, while potentially increasing the release of zircon stone defects; in fact it must be remembered that the resistance against soda-lime glass contact, for AZS fused cast, is mediate by a so called “passivation layer” that is none but a layer of high viscosity glass (high alumina, high zirconia) including few primary zirconia crystals, staying adherent to the refractory like a skin. Through this passivation layer, alumina and zirconia are slowly dissolved toward the matrix glass.

So, as a matter of facts, after experimental validation of these mechanisms, there was never an AZS refractory marketed at, say 50 or 60 or more percent of ZrO2.
was not counting on a passivation layer to resist glass corrosion. This was the High Zirconia fused cast (HZFC), a composition around 95% ZrO₂, with lower content of silicatic glassy phase than AZS and a very low content of alumina. The most important feature of this specialty product is the presence of monoclinic zirconia in form of relatively large crystal in a very interlaced structure, with thin layers (cushion) of silicatic glassy phase between crystals.

This interwoven structure makes it impossible releasing crystals at the interface glass-refractory.

Since Zirconia does not color the soda-lime glass, these materials were looking promising to be applied in throats with the aim to balance high-zirconia-AZS sidewalls for high pull and long campaign life furnaces producing extra white glass.

But it did not take a long time to understand that the lack of a passivation layer formation (there is not enough alumina in the refractory) at the interface glass-refractory increased the dissolution speed of Baddeleyite crystals, particularly in applications like throat, where the glass speed (and therefore the renewal of the contact surface) accelerates the phenomenon.

As a matter of facts, the corrosion resistance of HZFC in contact of a soda-lime glass, particularly in throat application, did not significantly improve versus traditional 41% AZS; in some case a marginal advantage did not justify the very large difference in commercial price.

The bad news was that not even HZFC represented the most wanted wide range solution for the orphan application niche, and the game is still open for future improvements.

The good news was that a new product, with very peculiar characteristics was now available for other than soda-lime applications, and in the course of these 40 years this specialty was representing a very useful (if not essential) condition to make it possible developing products that all of us utilize every day in several ways.

**Resistance issues**

The key factor for HZFC applications has been rooting on the same facts that made it disappointing in term of glass corrosion resistance: these materials do not generate any passivation layer at the glass interface, do not have alumina enough to do so and the interlaced structure of their large Baddeleyite crystals make very hard to strip out crystals, while zirconia is slowly dissolving in the glass, generating relatively large amount of glass at very low zirconia pollution.

All these conditions are the basis for a refractory having extremely low potential of defects: no alumina cords, no cat-scratches, no primary/secondary zirconia stones, no Al/Zr knots (coming from detachment of passivation layer shreds).

Amazing enough, this refractory was there, already before the marketing requirement revealed itself.

The first relatively large volume application for these special fused cast refractory was, therefore, in the CRT TV glass, particularly for the panel glass production. For these items is enough to say that one single defect in a piece (that can weigh a few kilograms) can easily led to rejection or declassing of a whole CRT. The premium in price of these HZFC refractories was, therefore, well justified by a substantial yield increase of an extremely quality-demanding and expensive glass.

Unfortunately for the refractorists that invested in developing HZFC (all the western players), CRT market did dramatically decline in a decade, due to the advent of FPD devices.

Apart for some minor utilization in Borosilicate, the other significant application was, and still partially is, in lead crystal furnaces, particularly for electrical shelf furnaces, where HZFC have been successfully installed in pavers (thanks to the resistance to downward drifing from Pb droplets), and partially successfully in the tin-oxide (SnO₂) electrodes holders. Once more, the decline of high-quality houseware market in a generally depressed western economy, the competition of other non-glass items, made it greatly declining these productions, where quality was, once more, the driving force for HZFC application.

As it often happens in our everyday lives, to the closure of a door corresponded the opening of a doorway. The same consumable that ruled the almost death of CRT went to open the way for yet another extremely demanding type of glass or, to be more precise, to a relatively large array of special glasses, representing the substrates of different families of flat panel devices, ranging from our smart-phones to computers, to large home-theatre television screens.

These substrates, based on different chemistries and different manufacturing technologies, have in common the extremely high demand of quality; this requirement brings along the application of HZFC. As a matter of facts, these extremely thin special glasses can be produced with float-like or “fusion” technology by a few globalized companies, but basically all of them utilize HZFC in the hot end of their special manufacturing processes. Particularly in the “fusion” process, the smelting units are largely (if not exclusively) electrically powered and the special (aluminate) glass exhibits unusually high electrical resistivity. Among the various peculiar characteristics of HZFC, the high temperature electrical resistivity is lower than any AZS (typically half than a high zirconia AZS) and can be close to the aluminate glass to be produced. Regular HZFC, therefore, could potentially become critical when installed in a electrically powered furnace smelting high-resistivity glasses.

**HZFC development**

The major western refractory makers producing HZFC have been, in the recent decades, investing seriously in developing special version of HZFC with higher electrical resistivity at working temperatures, basically working on the glassy phase chemistry to reduce its own electrical conductivity.

This has been not an easy task, and sometime requested compromising a bit other variables, particularly the corrosion...
Bucher Emhart Glass now offers forehearth channel blocks and introduces a new lightweight refractory material – EmLite 30

Bucher Emhart Glass forehearth refractory products
Bucher Emhart Glass is now able to provide complete refractory solutions for the forehearths, incl. channel blocks, sub- and superstructure and insulation. The 333 channel blocks are available together with high performance mullite superstructure.

Forehearth components are made with high quality, high purity materials. The workhorse material for forehearths is a mullite composition. This material is used for roof blocks, burner blocks, chimney blocks, and other various shapes. If a particular component requires a premium composition, an alumina fortified mullite is used. In colorant forehearths or other applications where corrosion is a concern, a zircon mullite material possessing excellent resistance to alkali vapor attack is used. The composition is also used for channel blocks and stirrer covers. Fiberglass forehearths require silica-free composition. For this application a zirconia toughened alumina is offered.

540 - The standard and most popular forehearth design. Two-humped roof block design for distributing heat evenly, keeping glass temperatures consistent throughout the width of the channel.

340 - More automated than the 540 design, with mechanical parts constantly moving the damper blocks back and forth on top of the flue blocks to better regulate air flow and temperature within the forehearth.

640 - Designed for smaller length forehearths which need more heat loss in the cooling zones. The smaller hump design on the roof blocks and modified cooling equipment prevent heat from being trapped towards the outside of the channel blocks.

240 - Most often used in narrow width forehearths (i.e. 16", 18" & 26" width). The design offers a flat roof block design where it is not applicable to use Bucher Emhart Glass “humped” roof block design.

Bucher Emhart Glass lightweight refractory material – EmLite 30
In order to withstand the heat and rigors of a glass plant, refractory covers must be thick and strong. But what if this could be achieved while also reducing weight?

Bucher Emhart Glass is introducing a new material for refractory covers that has all of the robustness of typical refractory materials, while at the same time reducing the weight of the part by 30% compared to covers made of a conventional mullite, such as Mix 345. This new material is called EmLite 30, with the designation Mix 310.

The weight reduction in EmLite 30 is achieved by increasing the porosity in the material, but still preserving its strength and resistance to alkali vapor corrosion. This increased porosity also has the effect of reducing the thermal conductivity of the material, giving the material an increased insulation value. Improving the insulation value above the spout will help to keep heat inside the spout and reduce the temperature of the covers themselves.

EmLite 30 is available in all front and rear refractory spout covers. The reduced weight eases the stress on the operators during installation. An 80 pound rear cover now weighs 56 pounds, an enormous difference when reaching over a hot spout for installation.

For more information please contact your nearest Bucher Emhart Glass sales office or consult our website.

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