In the latest of his series of exclusive foci for Asian Glass, P.Carlo Ratto discusses the more technical approach to fused cast manufacturing methods and how the advent of new modelling techniques is greatly enhancing the process.

It is now several years since western glassmakers have evaluated and put into practice variable level of low-cost procurement of AZS fused-cast refractories. Among these glassmakers, large global players, with strong technical offices capable of autonomous valuation or resorting to outsourced services, are now regularly acquiring materials for major repairs or furnace parts from low-cost sources; this policy implies a continuous process of review and technical evaluation of the supplier that consent, together with monitoring of the “delivered cost” evolution, to stay informed of the present ratio risks/benefits, since the main advantage stays on the economical ground.

Small and medium size glassmakers, on the other hand, when procuring low-cost do generally recur to third parties that generally are commercial intermediaries; the difficulty to autonomously evaluate the above mentioned risk/benefits ratio and the involvement of parties having commercial interests, makes it seriously complicated to understand the overall convenience of the operation, unless the glassmaker will resort to independent support, now finally available.

In several cases, however, principles of cautiousness prevail, so that large companies buying AZS fused cast from low-cost sources maintain a multi-sourcing criterion, keeping involved traditional western suppliers that often present the most critical furnace details for corrosion (e.g. the throat) or for the glass quality like alcoves, distributors, channels.

This policy is hardly manageable by small size glassmakers that, therefore, and as already mentioned, are much more exposed to the technical risk.

Progression in price
In the most recent years, we have witnessed a progressive attempt to buy low-cost fused cast alumina, generally from a selected number of suppliers already involved in the procurement of AZS refractories.

It should be specified that, at present stage, the low-cost providers are mostly involved in the supply of α-β alumina that, with exclusion of oxyfuel crowns, are mostly installed in the fining zone of float furnaces and in the after-throat portion of container glass furnaces, when the glass quality is a decisive factor.

From this peculiarity comes the fact that the determinants of the aforementioned risk/benefits ratio, for alumina, are very different from the case of evaluation of an AZS, and that many glassworks are even less equipped for a self-evaluation of this parameter.

The first users of cheap electrofused aluminas were regional float-makers (e.g. Russian) for which the financial aspect was dominant against the potential risk of quality; these users have installed, several years ago, materials that for organoleptic factors (color) would never have been considered by western glassmakers.

In fact, while for the electrofused AZS the core technology does not differ greatly from the no-hot-step sub-family of western technologies, with regards to the production of electrofused alumina there are marked differences not only to historic western producers, but also between the multiple independent low-cost players which, in many cases (and unlike what happened for AZS) have independently developed some parts of technology and know-how, clearly having effect on the tendency to generate defects in the glass in contact, once these refractories are installed in the typical applications of float or container furnaces.

It is worth at this point, to give some information about the technological aspects involved.

While most people believe that the heart of the technology and know-how of electrofusion is within the fusion in the EAF (Electric Arc Furnace), the reality is that among several critical areas of technology, many reside in the selection of raw materials and in the moulding technology.

Raw material movements
Regarding the raw materials, much has been investigated about the causes of discoloration of low-cost aluminas, especially as manifested in the early years of production; the blue-greenish coloring of α-β alumina, particularly intense in the zones of segregation of the β-alumina (close to the shrinkage cavity) where the light penetrates deeper into the structure, it is thought to be determined by the presence of heavy metals at the level of ppm.

Many researches and speculations have been made about the purity of the main raw material (some varieties of Bayer alumina) and related ingredients, to determine the causes of this anomaly, but without coming to a clear conclusion; some manufacturing steps in the fusion process could also be involved.

It is proper to mention the fact that they have never been described, to the best of our knowledge, problems related to colour of the glass produced in contact with “blue” alumina, particularly installed in many float furnaces Russia, China and other eastern countries.

In all cases, however, the discoloration of these aluminas, has been for years an almost insurmountable obstacle to sell them to major western producers of float, container and other glasses, when high quality was to be granted.

In terms of colour, at present, significant improvements have been made by certain independent low-cost manufacturers, although a slight blue colour frequently remains as distinctive of these aluminas.

Following many technological audits performed at leading independent low-cost producers, well we can say that the production technology of the moulds,
is indeed the main distinguishing feature of each individual producer that, unlike what happened with the development of the AZS technology, generally manages a know-how individually developed in the manufacturing steps comprised between casting and machining, that is, the production of moulds, their flasking, subsequent annealing and cold extraction.

To better understand this issue, one must consider that the alumina, at the liquid state, is about 150 °C warmer than the fused AZS, and therefore moulds made out of silica sand (used for AZS production) are here almost unusable, even in consideration of the fact that alumina would react with silica originating liquid phases and nullify, resulting in fusion lumps at the hot spots of the mould and in an unacceptable contamination of the block surface.

The western producers, starting from the Carborundum/Monofrax in 1933, have developed and optimized the use of moulds based on graphite plates, progressively optimized with special treatments, to ensure the required refractoriness, rigidity at high temperature and chemical inertness.

The graphite moulds, inherently expensive, however, have the advantage of being able to be re-used when more than one block of the same shape is cast (for example for channels and sidewall blocks), through a process of regeneration and surface protection that allows to maintain the efficiency and effectiveness of the graphite components, for a certain number of twin items to be cast.

For a number of factors including the unavailability of suitable materials and local lack of specific know-how, low-cost independent producers have developed a number of alternative technologies, whose common denominator is the use of a panel made out of a granulated mineral being more refractory than silica, bonded with agents ranging from the most classical inorganic, such as sodium silicate (waterglass), to suitable organic resins like those based on furan or phenol-formaldehyde-urea.

Mineral options
Some options are possible with regard to the mineral base, and the first choice that appears obvious is the use of high temperature sintered alumina, typically “tabular”, which must be dosed with a mix of different selected grains, to obtain a panel of sufficient strength from the mechanical point of view and permeable to evacuate the gases produced in the initial stages of contact with liquid.

The use of a very expensive raw material, the need to provide a relatively sophisticated flasking package to ensure proper cooling and to contrast the hydrostatic pressure in the early stages of cooling, the obtaining of a skin of casting very rough and of course the fact that this mould is inherently “one-way”, are factors that can increase the operating costs of such technology to the limit of feasibility, without considering the need, at the end of cooling, to dispose a large amount of contaminated mould residues (especially if waterglass is used as binder), very difficult to recycle.

Another option adopted for the mineral base by some low-cost manufacturers is the use of selected grains of medium-high purity periclase (MgO), bonded with an agent generally, but not exclusively, made of waterglass. Some parts of the moulds can also be produced from grains of the same electrofused alumina, similarly bonded.

One must consider that the periclase presents a certain instability to storage, particularly for the fine particle sizes (hydration) and that this problem is transferred to the moulds, particularly when linked with a binder based on aqueous medium and/ or hygroscopic (waterglass). In addition, these moulds still require a complex flasking package comprising different materials and components; all these factors result in a considerable difficulty to master this technology and to a massive generation of waste products since this package is, once again, “one-way”.

It must also be considered that the skin contamination with grains of periclase (MgO) of the fused cast alumina block, particularly those surfaces that will go at glass contact, constitutes a possibility as unacceptable as unavoidable when such a technology is used. To minimize the risk aforementioned, the producer has no other solution than to grind thoroughly all surfaces to go in glass contact, in order to remove the surface contamination together with the porous range under the skin. This practice, in itself very costly in terms of time and money, is further burdensome considering that a significant part of the α-β alumina product mix consists of channel blocks, whose glass contact surface is curved (U-shape) and can be ground only by mean of non-standard equipment.

Carbon calling?
Whatever mould technology for aluminas, when it is not based on graphite slabs, the common factors are the unrecoverable nature of the moulds (one-way), their complicity, the need to produce a package for insulation-stiffening of the flasked moulds (so as to govern the optimized cooling curve) and, at the process tail, the production of a large amount of rejects when different mineral components are hard to separate and very difficult to recycle, the disposal of which is (and will be in the future) an important cost component.

Another common point of these technologies is the need to grind heavily (2 or 3 mm beyond the flatness) all surfaces in glass contact to remove the surface contamination from minerals constituting the mould main component, to prevent cession of defects to the glass in contact.

In conclusion, if it is inevitable that more and more western glassmakers will turn to low-cost procurement of alpha/beta aluminas (at least as long as there will be a substantial economic advantage), and as long as the low-cost independent producers will not develop the graphite-based technology (or another inherently “clean”), those glassmakers need a thorough understanding of the specific technology used by the selected manufacturer, becoming aware of the type and intensity of the associated risks, and to develop specific testing protocols that enable to minimize the possibility of contamination.

The acquisition of low-cost aluminas from independent producers, even if possible, it is therefore not currently recommended without a specific technical-technological knowledge, making it possible the risk reduction through appropriate modalities of control. Unlike the AZS situation, in fact, the various manufacturers of electrofused aluminas manage different technologies, leading to specific risk components.

The good news is that this type of support is currently available and practiced, allowing anyways a conscious and informed decision based on a risk/benefit ratio in the procurement of low-cost aluminas for glass furnaces.

Typical low cost alpha-beta alumina, showing light blue discoloration and surface contamination from moulding components”