Scaling up electric melting for the glass industry

Pic 1. Prium E-Melt of 160 tpd at Verallia Cognac, France.

Andy Reynolds* discusses Fives' role in installing the world's largest all-electric furnace for glass packaging at Verallia's Cognac plant in France.

The commissioning of an all-electric furnace at the Verallia's Cognac plant in France marked a pivotal year for both Verallia Group, the world's third largest glass packaging producer, and Fives, an international engineering group.

With a nominal capacity of 160 tpd and producing high-quality soda-lime glass for premium spirit bottles, Prium E-Melt is now the largest all-electric furnace operating in the glass packaging sector in the world (***Pic 1***).

This project is a key step for Verallia in its ambitions to decarbonise glass melting. For Fives, this is an important validation of its Prium E-Melt technology for larger scale applications. The project marks an evolutionary step towards furnace sizes more commonly used in present day container production.

Why electrification?

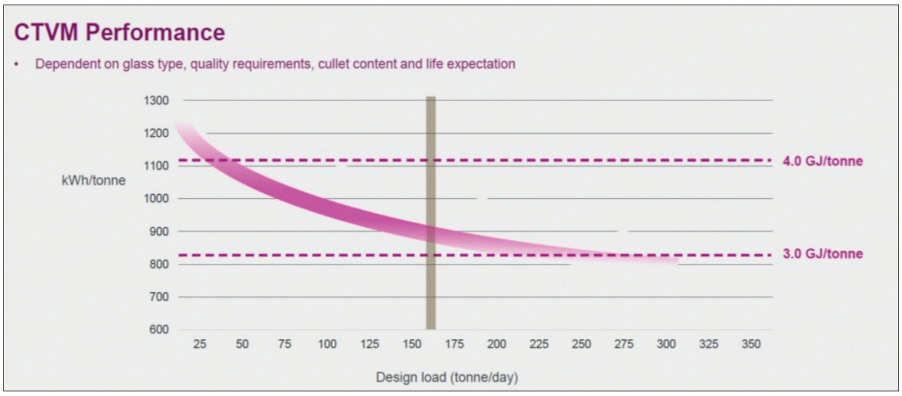
Glass manufacturing, an energy intensive industry fuelled largely by gas combustion, is a significant contributor to industrial CO_2 emissions and, of all process elements, melting is by far the biggest contributor.

A typical container glass furnace running at 320 tpd with 50% cullet and natural gas-firing at a modest specific energy consumption of 4.5GJ per tonne, produces approximately 70 tonnes of CO_2 per day purely from combustion. Adding another 30 tonnes per day from the glass melting reactions (decomposition of carbonates) gives a total of 100 tonnes of CO_2 a day, over 300 kg of CO_2 per tonne of glass produced. To put it another way, 25% of the total mass output from the furnace is gaseous emissions!

From the perspective of potential carbon reduction, exchanging gas heating by electricity only makes sense if the electricity is relatively 'green', otherwise we simply exchange Scope 1 CO_2, produced by the process combustion, for Scope 2 CO_2, produced by electricity generation.

Gas combustion in the furnace generates approximately 185 g CO_2 per

Continued>>



Pic 2. Specific consumption curve versus design load.

kWh-equivalent power input. If each kWh of electricity 'costs' around 300 g of CO_2 to produce (the approximate European average today), then even accounting for the resulting increase in furnace efficiency, applying say 15% electrical heating (e-boost) to a regenerative furnace makes little difference to the overall combined Scope 1 & 2 emissions.

Higher e-boosting levels actually increase overall emissions. Clearly, in this narrow context, high electricity levels or full electric melting makes no sense unless there are other considerations or technical advantages gained, which indeed is often the case.

In France, however, the carbon cost of electricity is less than 30 g CO_2 per kWh due to high percentage of nuclear and renewable sources. In such an environment, replacing gas consumption with electrical heat will dramatically reduce overall emissions.

At the nominal load of 160 tpd the Prium E-Melt furnace at Verallia's Cognac plant has a specific consumption of only 3.2 GJ per tonne of glass. With zero combustive CO_2 the remaining 30 tpd from the melting reactions represents a 60% reduction compared to original end-fired technology.

Even for regions where the carbon cost of electricity is higher, electrification of melting may have merit. Furnaces have significant lifespans and investment strategy must consider the long term.

Electricity generation is becoming greener due to ever increasing renewable sources. For many countries CO_2 per kWh levels have reduced by 100-200 g in the last 10 years, with accelerating trends.

The UK achieved under 130 during 2024 – well below the 185 'crossover' threshold gas to electric. By 2026, much of the EU will be below 200. The transition from gas to electric glass melting is therefore expected to gain pace within five years – driven too, by strong consumer demand for sustainability and increasing legislation aimed at incentivising carbon reduction.

Electric melting

The objective of Verallia's Cognac project was to replace an existing 320 tpd end-fired furnace with two 160 tpd all-electric furnaces. The first Prium E-Melt furnace was commissioned in April 2024.

The obvious question is why not a single larger unit rather than two smaller ones as planned. The answer comes from a need to mitigate technical risk by keeping close to proven design configurations. The Prium E-Melt furnace in Cognac, although new in terms of scale and containing modern elements, is based on principles well proven by Fives in smaller scale applications.

Furnaces using the cold-top vertical melting principle (CTVMs) are now commonplace in cosmetic and pharmaceutical sectors with capacities generally less than 100 tpd.

Melting at between 1.7 and 2.2 tonnes per m^2 per day, depending on composition, cullet ratio and process parameters, the melt areas of these tanks range up to only 50 m^2.

For high-quality soda-lime, a 320 tpd furnace optimised at 2.13 tonnes per m^2 per day, would require a melt area of 150 m^2, a substantial step from 50 in both structural design and process engineering.

At 75m^2, 160 tpd was considered a manageable technical advancement from what was already proven, whilst providing a positive step on the road towards larger units.

One point worth mentioning: electric furnaces are inherently energy efficient. Besides the energy required for melting, energy input only needs to make up for direct structural losses and these are relatively low because the superstructure (the crown) is cold, and there is an absence of heat recovery structures such as regenerators.

The ratio of structural losses to melt energy is therefore lower than in conventional furnaces. This means that by the time we get to the furnace sizes required for 160 tonnes and above, the curve of specific consumption versus design load has already flattened.

Doubling the size of an all-electric furnace does not therefore reduce the specific consumption significantly (***Pic 2***). OPEX gains of larger tanks, a big driver for increasing the sizes of regenerative furnaces, is much less relevant for electric melting. Nevertheless, Fives has continued to move forward on developing concept designs for larger tanks up to 150 m^2 (***Pic 3***).

Design

The Prium E-Melt furnace has a number of unique design features. Ensuring a uniform batch layer across such a large area is critical to stable operation and this is achieved with an electrode configuration and connection arrangement coupled with a purpose designed batch charging system.

Power is supplied through variable output transformers – the system having a total installed power of 9MW. The furnace is constructed with an integral air-cooling system where the cooling draft is channelled through structural steelwork, thereby reducing the need for external ducting, and in turn facilitating good access to the refractory parts for maintenance.

In vertical melting we have only tank geometry to control the thermal profile and flow pattern required to enable melting and fining processes, and the correct separation between them. The location and orientation of electrodes, sidewall shape, and the relative distance above and below the shelf structure, were all specifically formulated through extensive CFD modelling. The resulting tank is over 4 meters deep from glass level to throat and this required advanced construction features to ensure secure melt containment.

In all-electric furnaces up to now, the final 'conversion' to cold-top operation (after initial warm-up of the structure and filling with cullet) has been done

Continued>>

by a largely manual and labour-intensive operation. These past procedures become less practical with larger melt surfaces. In the Prium E-Melt furnace in Cognac features were added to allow easier conversion including, for example, ports in the crown with specially designed water-cooled venturi nozzles enabling automatic feeding of cullet and/or batch into the pressurised furnace chamber onto the central regions of the melt surface.

With green electricity, France provides particularly fertile ground for electrification of glass melting.

Fives implemented contracts for other electric furnaces in non-container sectors, including a 70 tpd all-electric furnace for luxury glass packaging at Pochet du Courval.

Technologies

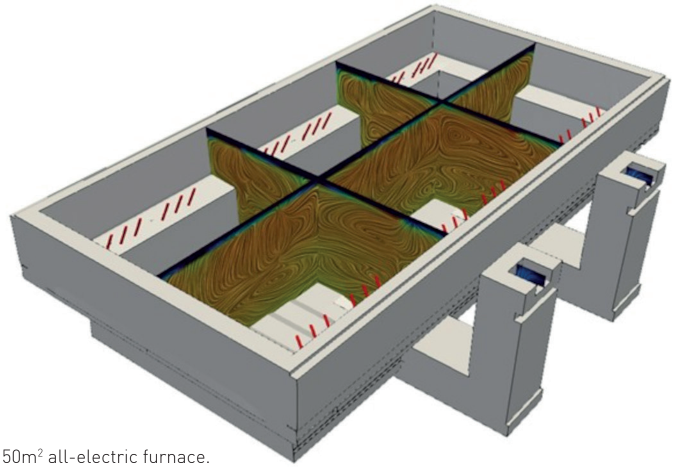
All-electric CTVM furnaces do have limitations in terms of flexibility and melting of reduced glasses can be problematic. In cases where a higher output range or compositional flexibility is required, then hybrid technologies maybe preferable.

In parallel to its work on all-electric melting, Fives has also developed its Prium Eco-Flex hybrid furnaces, one of which will be delivered in France for an international container glass producer.

There are other ways to reduce CO_2 emissions and indeed, benefits can be made by simply improving furnace efficiencies. Several technologies including, for example, batch preheating, and improved heat recovery are maturing. Then, there is the possibility of using clean fuels such as hydrogen or employing carbon capture.

These technologies however, whilst having strong merit worthy of investigation and development, do not yet have the technical readiness level to help the industry in the shorter term. Electrification is currently favourable because the associated technologies are relatively mature, other options suffer from lack of scalability and/or lack of resources or fuel availability.

In the future, glass melting is likely to be more diverse than today with the application of different and combined technologies. Electric melting in both all-electric and hybrid will have a big part to play. We can look forward to a cleaner and more sustainable industry. ■



Pic 3. Concept design for 150m² all-electric furnace.

*Business Development Director – Glass, Fives Group, Paris, France
www.fivesgroup.com/