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Amping up the power of sustainable glass production

Dr. Lars Biennek discusses options for incorporating more electric power directly into the glass-melting process and shares HORN's solutions for hybrid technology, all-electric furnaces and electric forehearths.

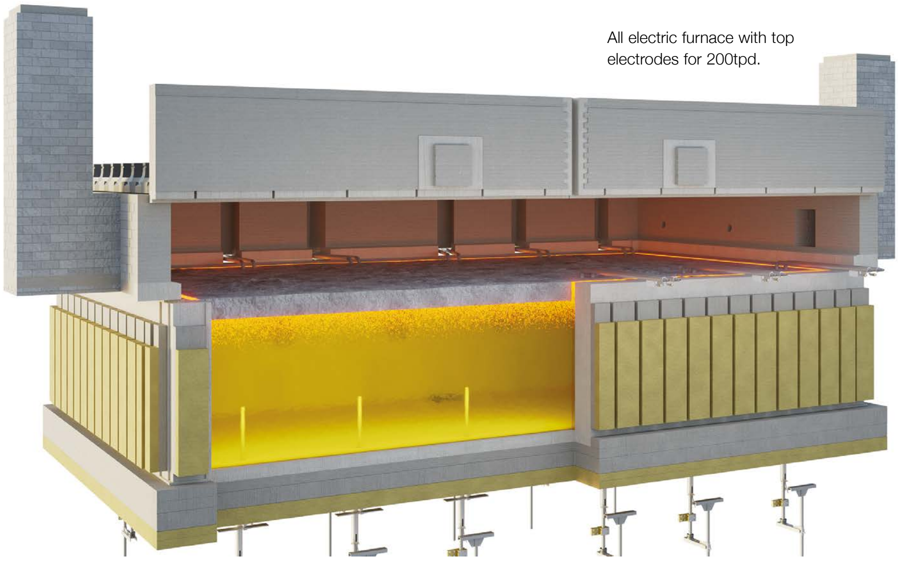
The risings costs of fossil fuels, at least in big parts of the world, and a general pressure in the reduction of CO_2 is driving industries of all kinds to explore and use alternative energy sources. This of course includes the glass industry. As a supplier, HORN has made considerable efforts to create fitting solutions for the glass producers to tackle these kinds of challenges.

An initial idea and in some ways the most obvious solution is the direct substitution of fossil energy sources with green alternatives. Biogas or green methane can be used as a direct replacement for natural gas. Hydrogen, which is at the centre of a lot of talk, is another option.

However, low efficiency in regards to the (electric) energy input is a problem for most of these substitute solutions. Therefore, is it not more logical to skip the detour over artificial fuel and incorporate more electric power directly to the glass melting process?

HORN's concepts for this can be put into three groups:

- **Hybrid technology:** Increase the electric power input in a classic set-up (end or side-fired) to 40% or even 80%.
- **All-electric furnace:** Use existing all-electric melting technology and update it to match the requirements of glass producers outside of high quality and specialty glass.
- **Electric forehearths:** Applying electric heating not only in the melting process but also in the glass conditioning and distributing.



All electric furnace with top electrodes for 200tpd.

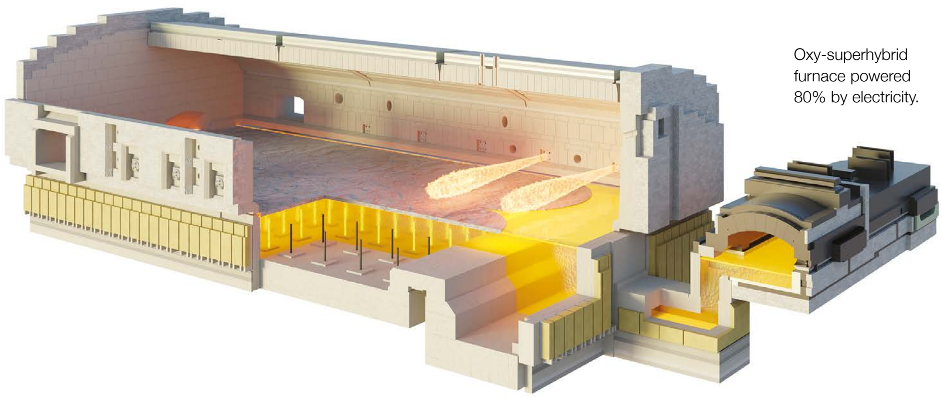
Hybrid furnaces

HORN divides the furnaces into three basic categories dependent on their electric share:

- **Boosted (Classic):** with up to 20%, which represents the upper limit what is already done.
- **Hybrid:** ranging from 20 to 40% for end-fired regenerative furnaces and up to 50% for oxy-fuel furnaces.
- **Superhybrid:** from over 50% to 80% of electric share for oxy-fuel furnaces.

The two hybrid categories bring some challenges to the design and the concept of the furnace. Temperatures for different parts of the furnace will differ (greatly) from what is experienced in the more classic set-up. Lower temperatures in the superstructure are the result of reduced fossil combustion and require an adapted refractory concept (lime-free silica <-> standard silica). The high electric input on the other side will increase the glass temperature in the distributor. Combined with a steep increase of convection due to the influence of a high number of electrodes, corrosion especially of the tank bottom, is expected to be much higher. Hence, a modified refractory and cooling concept is necessary.

One main goal of hybrid furnaces is to maintain the horizontal melting process that is the well-known principle of classic fossil fuel furnaces. For an oxy-fuel furnace, the distribution of a multitude of burners along the glass ▸



Oxy-superhybrid furnace powered 80% by electricity.

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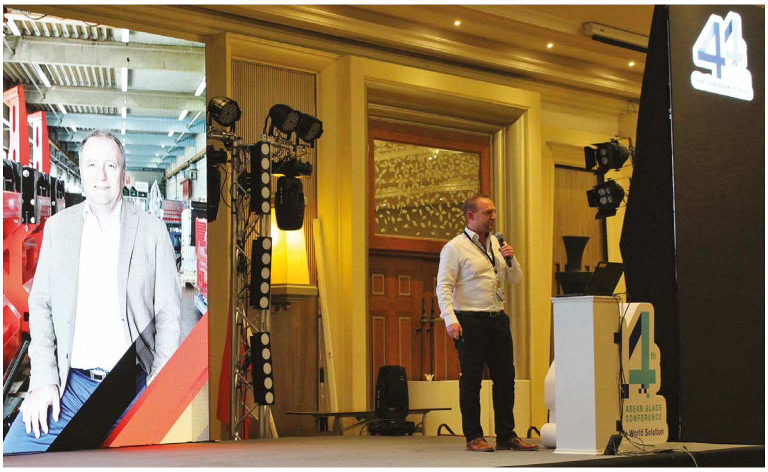


Dr. Lars Biennek presenting at the 44th ASEAN Glass Conference in Pattaya, Thailand in November 2022.

flow allows for a very good tuning of the temperature profile to match that of a classic furnace. Only in instances of very high flexibility is the addition of a shadow wall to divide the superstructure into two parts deemed necessary. Other additional features, dependent on size, quality and flexibility, could be a refining shelf, a deeper refining part and the possibility of flue gas recirculation to increase the burner port velocity and secure a proper flame formation for hybrid end-fired furnaces.

All-electric furnace

With an extensive history, all-electric melting is anything but 'brand new'. Nowadays it is used mostly for high quality or specialty glass, because some challenges hamper production – for example, container glasses. These culprits are a limited maximum pull rate (<200tpd), restrictions regarding flexibility of pull changes and cullet fraction and a shorter lifetime. HORN is tackling these disadvantages to overcome them or at least soften their impact.

Upscaling of an all-electric furnace is crucial to meet the needs of glass producers, because a pull rate of 200tpd is currently around the lower end of the scale for the production of container glass (not to mention flat glass). To achieve that, HORN is shifting from the round (octagonal or dodecagonal) shape to a rectangular one for bigger all-electric furnaces. For a round furnace the distance between the top electrodes would be much higher in an upscaled version (80% increase by going from 60tpd to 200tpd). The direct result would be a high instability in the melting process. In the rectangular set-up, the distance would only be 10% higher and the process would still controllable. The rectangular furnace is a proven furnace shape. This furnace type has been successfully installed and operated for decades by HORN's daughter company JSJ Jodeit.

In the most current all-electric furnaces, flexibility regarding changes of cullet fraction and pull rate is very reduced. This can mostly be attributed to the stability of the insulating batch layer on top. Changes on that layer by using more or less batch can lead to an insufficient thermal exchange between glass and melt, or the creation of holes in the layer, and subsequently a high thermal loss. By using a higher depth of the furnace, the residence time of the glass is increased. If the changes in cullet fraction/pull rate require a reduction in the electric power, the longer residence time helps to secure the glass quality even with the lower electric input (and therefore lower temperature level). Being able to operate the furnace at a lower temperature level will also help to increase its lifetime.

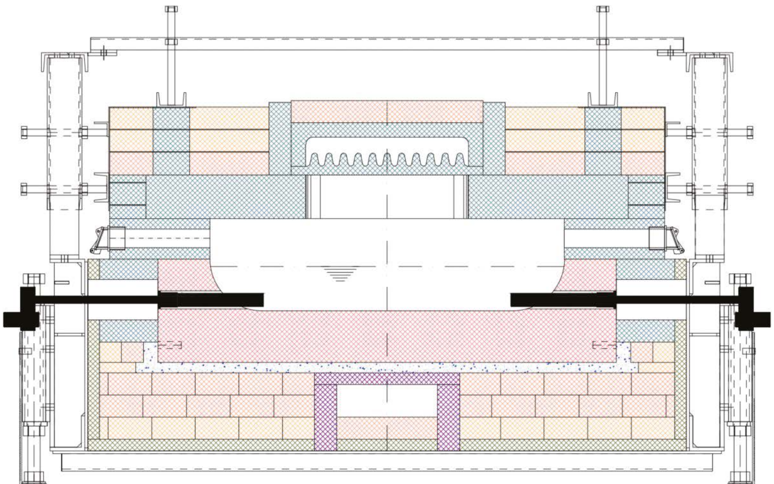
Electric forehearths

While most energy is consumed by the melting process, the glass conditioning and distribution is also an area where a switch to electric heating can save fossil fuel (and potentially money). Options for electric heating include a direct and an indirect solution. For direct heating, molybdenum electrodes are installed in the glass bath. This can be used for reduced coloured glasses but can lead to defects with oxidised flint glass (sulphate fining).

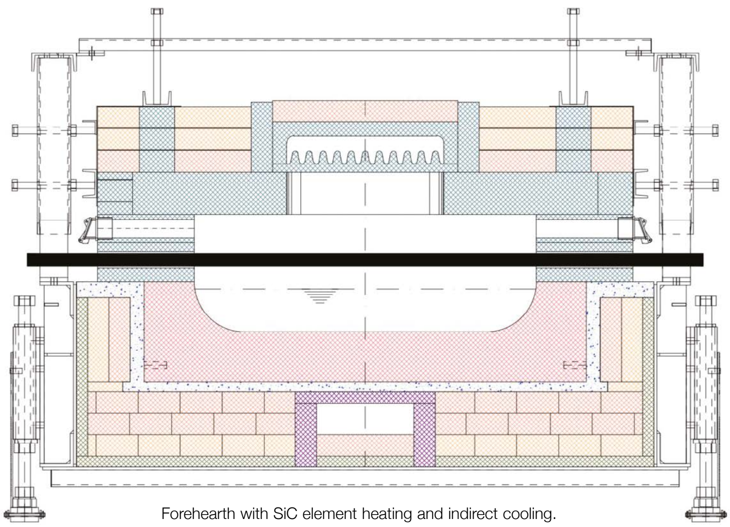
For ensuring the redox state of the melt, any direct cooling is not recommended. But cooling with only indirect cooling can limit flexibility.

For indirect heating, SiC electrodes are placed above the glass melt. Glass colour is not a factor here, but the restriction of indirect cooling also applies.

High investment cost for these electrical heating systems (and their restrictions) must be weighed against the long-term potential of energy savings (70% up to 85% for 120tpd example) in such a case. ●



Forehearth with electrode heating and indirect cooling.



Forehearth with SiC element heating and indirect cooling.

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