GLASS MELTING TECHNOLOGY

HORN
GLASS INDUSTRIES

innovation
ENGINEERED IN GERMANY

GLASS MELTING TECHNOLOGY

HORN® Glass Industries AG is a glass melting technology specialist who supplies the float and container glass industry with a wide range of high-quality individual products and turn-key plants. The high performance glass melting furnaces and turn-key plants are planned, built and delivered to glass manufacturers all over the world to produce beverage bottles, food containers, drinking glasses, window panes, automotive glass, glass tubes, glass fibres or specialty glass.

With more than 135 years of experience in the construction of glass melting furnaces HORN® is well known as a specialist and expert in the glass industry. Over the years, HORN® has extended its capabilities and expertise and has grown from being a glass melting furnace manufacturer into an industry leader in technological plants.

The group has also grown considerably with subsidiary companies in China, Malaysia, India, Croatia, Ukraine, Brazil and the Czech Republic, adding value – such as proximity and short response time for global customers. Almost 90 % of the products are exported from the HORN® headquarters in Plössberg (located in the Bavarian Upper Palatinate, Germany) to more than 75 countries worldwide.

At all times, HORN® offers its customers full support and a helping hand. Due to a very high level of vertical integration of all products, HORN® offers tailor-made solutions and, at the same time, has ventured into new areas, e.g. in the construction of proprietary tin baths and related equipment. HORN® manufactures a wide range of products in its own workshops in Plössberg and is the service provider for the realisation of customer visions and projects in the field of glass production. HORN® supports its customers from the first draught through the implementation process to permanent production support on-site.

HORN® builds a wide variety of glass furnace types for its customers, ranging from the usual end fired furnace to the all electric melting furnace. Furnace selection depends on individual customer requirements and demands.

Depending on glass quality, furnace capacity, raw material specifications and glass type, each furnace is customised and optimally designed in compliance with the requirements of the customer.

HORN®'s know-how and experience of many years concerning the optimisation of energy consumption and emissions are also reflected in the sophisticated design of all melting furnace components.

HORN®'s scope of service and supply:

- Melting technology and know-how
- The design of steel, refractory, piping, cabling, control systems and equipment
- Refractory supply
- Heat-up and Start-up
- Optimisation of melting process
- Trouble shooting

Although our technology is state-of-the-art, we nevertheless continue to strive for the development of innovative technologies such as large scale all electric and hybrid furnaces, new measuring devices, new equipment and related control strategies.

Important factors for selecting a melting furnace concept can be:

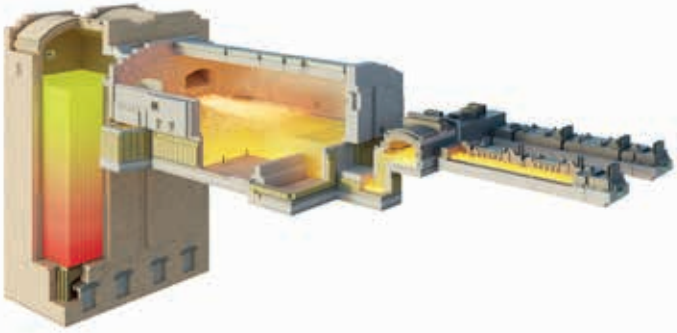
- Melting capacity, glass colour, product type, requirements concerning the glass quality, etc.
- Medium for firing of the furnace, such as natural gas, oil, LPG and the possibility of using oxygen
- Environmental requirements or other legal requirements
- New construction or replacement of a melting furnace already in place
- Space conditions in the melting furnace building

DIFFERENT FURNACE TYPES

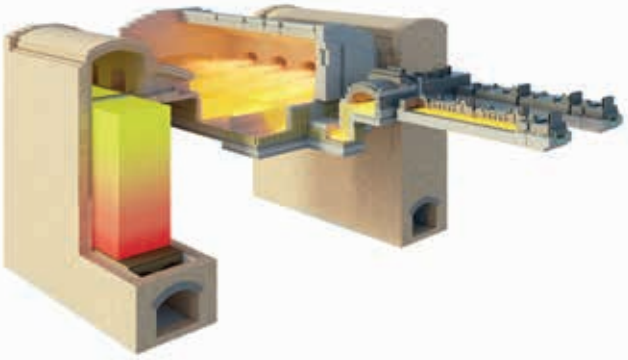
HORN®, with its extensive experience, expert knowledge and expertise, designs different types of furnaces best suited to the various glass melting processes.

Furthermore HORN® considers local circumstances like energy prices and environmental regulations. **HORN® Glass Industries AG supplies the following furnace types:**

Regenerative End Fired Furnaces



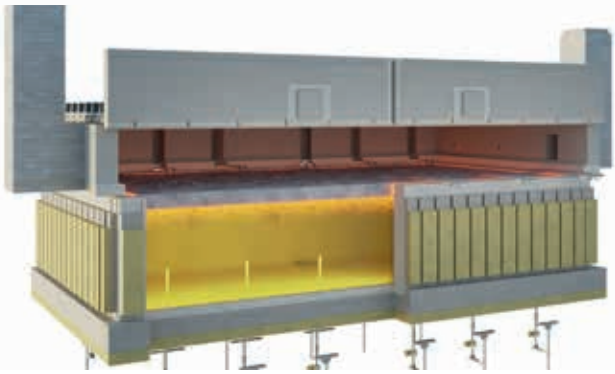
Regenerative Cross Fired Furnaces



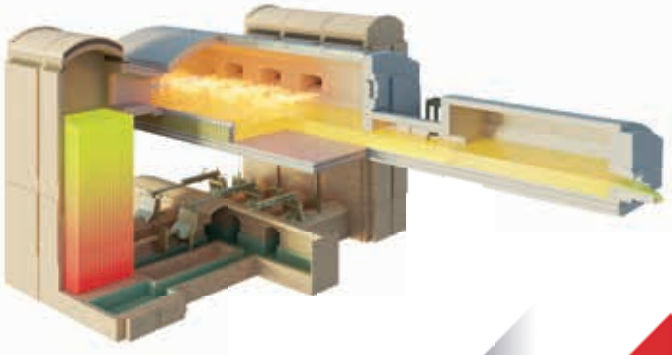
Oxyfuel Furnaces

Recuperative Furnaces

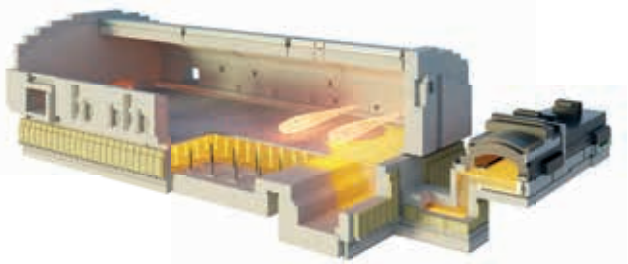
All Electric Furnaces



Float Glass Furnaces



Hybrid Furnaces



END FIRED FURNACES

GENERAL

Due to its high flexibility and its low energy consumption the regenerative end fired furnace is the working horse of the glass industry. Most mass produced glass products such as bottles and containers of all kind, tableware and glass fibre can be produced with a minimum of fossil fuel firing and thus carbon dioxide emission. Its typical melting capacity is 30 – 500 t/d, in some cases up to 700 t/d can be achieved. Limitations in furnace size result from flame length and crown span width of melting tank as well as burner ports.

DESCRIPTION

If sufficiently dimensioned, the regenerators maximise heat recovery of the melting end firing and thus ensure an optimal reduction of energy consumption of the glass melting process. Slightly larger regenerators than necessary are an investment for the future, reducing maintenance effort and common energy consumption increase due to ageing. Additionally this allows a furnace enlargement at the next furnace repair with reduced glass-to-glass time and costs, when reusing the basic design and lower part of the regenerator.

By designing the ports and superstructure properly very low emission values in respect of NOx and CO_2 can be achieved. Since there is only one alternating flame in glass flow direction, its optimal adjustment is crucial for the glass melting process. After furnace startup the first setting is usually done by experienced HORN® combustion specialists for optimisation, ensuring an optimal melting performance from the start.

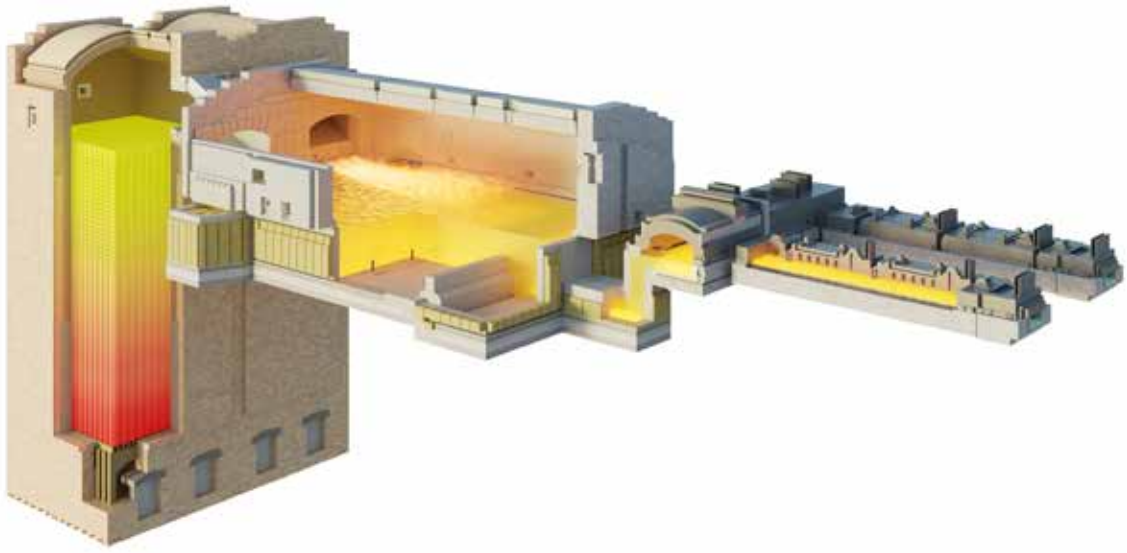
FEATURES

- **Low energy consumption**
- **Low emission values**
- **High flexibility in case of load change**
- **High specific melting output**
- **Long furnace campaign**

A weir wall in the melting end, also called barrier, and a deep refining part increase flexibility and glass quality.

The barrier supports the main convection of the melt which improves melting and refining. Additional electric boosting improves furnace flexibility and is advantageous in case of coloured glass production.

Additional lances or burners at the furnace sidewall can be mounted in order to lower NOx emissions by staged combustion or increase melting capacity by oxyboosting. Most common is the application of a pressurised air lance in order to lower NOx and generally improve melting. This technology is known as ggENOx and can be applied also while furnace operation. It is most suitable to improve furnaces not showing a good performance.



CROSS FIRED FURNACES

GENERAL

In comparison to other furnaces, cross fired furnaces can be designed in larger overall dimensions due to the larger firing zone because of the lateral arrangement of the burners and port necks. The only limitation is the furnace width due to crown span length. Typical melting capacities are in between 250 – 500 t/d, but also 750 t/d or more are possible. Similar to the end fired furnace the regenerative cross fired furnace ensures low energy consumption due to heat recovery system and high flexibility regarding load changes.

The energy consumption of a cross fired furnace is usually slightly higher than that of an end fired furnace.

DESCRIPTION

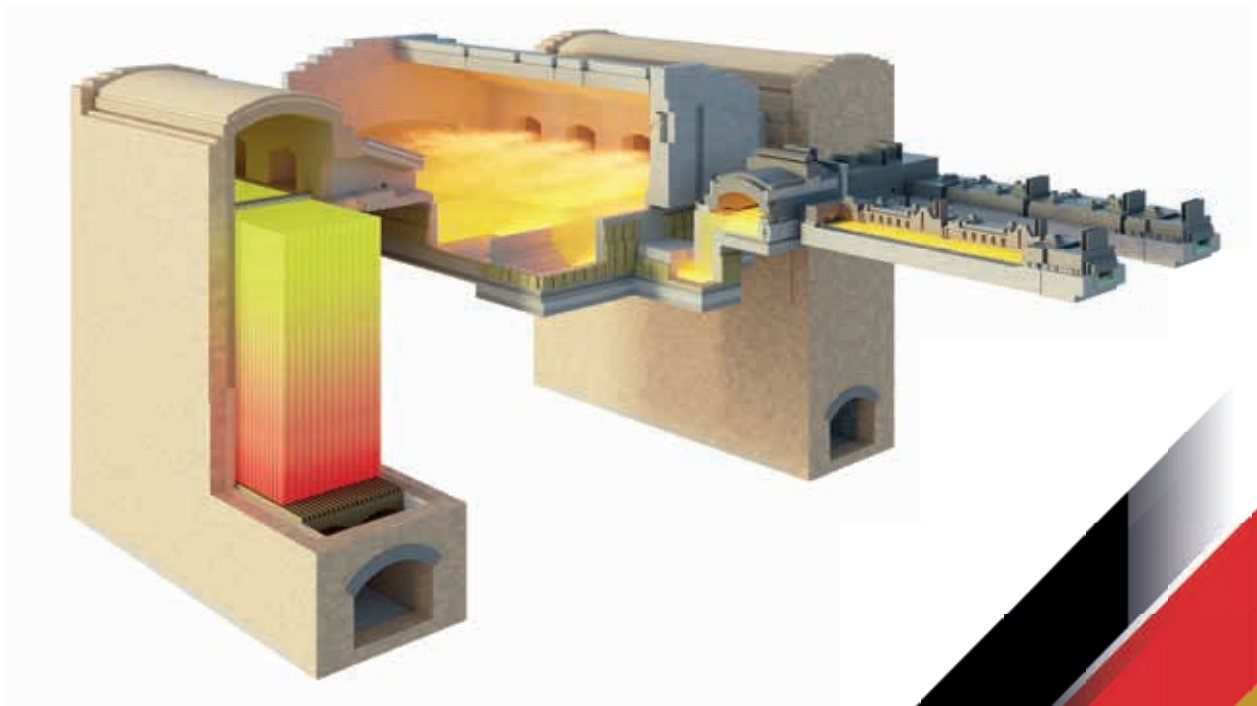
The regenerators, port necks and burners are positioned laterally. A separate chamber (sectional regenerators) together with an independent flue gas reversal system can be designed for each port neck. This ensures precise control of the furnace temperature over the entire length of the melting furnace. Often the flue gas from multiple port necks or even from all port necks is discharged via one chamber for cost reasons.
In case of environmental restrictions in respect to NOx emissions, this furnace type can be equipped with sideport burners instead of underport burners. Due to limited adjustability and port width, more ports are generally required. Because of the higher number of ports usually one or two regenerators are built on each side of the furnace in this case.

FEATURES

- **Furnace capacity up to 750 t/d and more**
- **Easily adjustable temperature profile**
- **High flexibility in case of load change**
- **High specific melting output**
- **Low energy consumption**
- **Low emission values**
- **Long life**

The regenerator chambers can be equipped with different checker types and qualities according to the position of each port. This facilitates the implementation of a furnace suitable for the raw materials used, with a long life and achieving the perfect melting process. A weir wall built into the bottom of the melting end, which is also called barrier, and a deep refining part increase the flexibility and glass quality.

This furnace type can be also equipped with electric boosting in order to increase melting capacity and flexibility.



OXYFUEL FURNACES

GENERAL

Oxyfuel furnaces are usually designed as cross fired furnaces where the fuel used (mostly natural gas) is combusted together with oxygen. The greatest advantage is in the low energy consumption and extremely low NOx emissions, since little or no nitrogen is aside during combustion. Compared with a cross fired or end fired furnace the energy consumption of an oxyfuel furnace is reduced by approx. 5 – 10 %, compared with a recuperative furnace the reduction in energy consumption is even 25 – 40 %.

DESCRIPTION

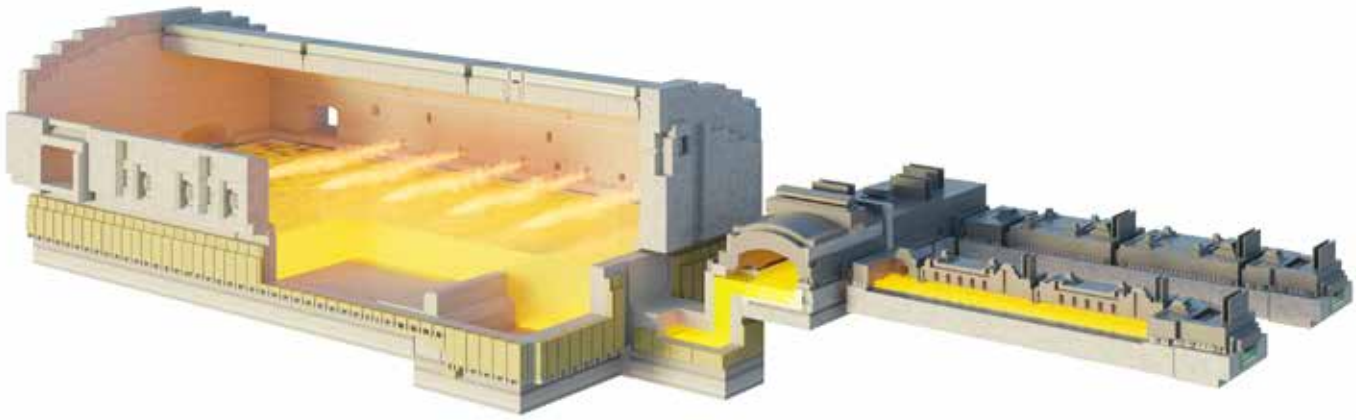
HORN® oxyfuel furnaces are specially designed for the particular characteristics of firing a furnace with fuel and oxygen. Especially the reduced flue gas volume requires a modification of the superstructure design.
For longer life, the exhaust can be placed rather in direction of the middle of the furnace or even near the throat thus ensuring an adequate heating in batch charging area due to burners in this area and reducing carry-over (dust). Too high flue gas velocities in exhaust and subsequent piping can lead to difficulties in furnace pressure control and can even lead to high furnace pressure due to insufficient flue gas flow rate.

Cold spots would lead to damages due to the infiltration of alkalis which cause burnouts in the arch, thus leading to reduced furnace life. To avoid such problems the HORN® oxyfuel furnaces are therefore adequately insulated and sealed.

FEATURES

- **Low investment costs for flue gas equipment due to low flue gas volume**
- **Low energy consumption**
- **Higher melting surface load**
- **Reduced NOx emission**
- **High glass quality**
- **Low investment costs for refractories**
- **Easily adjustable temperature profile due to lateral arrangement of burners**
- **Shorter time from glass to glass**

In general oxyfuel furnaces are used for a melting output of 50 – 400 t/d, in some special cases as small as 2 t/d specialty glass. The maximum furnace size is approximately the same as for regenerative cross fired furnaces, i.e. 750 t/d and even larger.



RECUPERATIVE FURNACES

GENERAL

Recuperators for small furnaces (up to 80 t/d) are double shell recuperators consisting of two concentrical pipes. For melting capacities between 100 – 450 t/d tube bundle recuperators are used. The air preheating output of recuperators is far below the output of regenerators. That is why the energy consumption of a furnace with recuperators is relatively high. An advantage, however, is the higher flue gas temperature enabling energy recovery possibilities like a steam turbine generating electric power. The continuous preheating of the air and the total separation of combustion air and flue gas leads to a more clean and stable combustion and thereby to better glass qualities. The specific melting capacity is lower than that of an oxyfuel or regeneratively heated furnace due to lower flame temperature and consequent worse heat transfer.

DESCRIPTION

For this furnace type air casing burners specially developed by HORN® are used. These burners ensure even distribution of the combustion air around the burner lances. The furnace is usually designed as cross fired furnace. Recuperative end fired furnaces are usually very small and rare. Even more rare are recuperative end fired furnaces with ceramic recuperators, which normally have a shorter lifetime of the heat recovery system.

FEATURES

- **Stable combustion since no fire reversing as with regenerative furnaces**
- **Easily adjustable temperature profile over the furnace length (for cross fired furnaces)**
- **Lower NOx emission than with regenerative furnaces**
- **Lower investment costs**
- **Less floor space required**
- **High flexibility during load change**
- **Long furnace campaign**

The typical features of this furnace type are the low melting surface load and the low investment costs. The glass quality can be higher at low pulls. It can also be equipped with a weir wall, a deep refining part and electric boosting systems in order to increase furnace capacity and flexibility.

ALL ELECTRIC FURNACES (COLD-TOP)

GENERAL

In general all electric furnaces following the cold top technology are typically used for a production range of 5 – 80 t/d. It is possible to increase the melting capacity up to 200 t/d and more. For this furnace type energy is not supplied by means of fossil fuels, but exclusively by means of electric energy supplied by molybdenum electrodes.

DESCRIPTION

It is possible to use rod electrodes with specially developed, water-cooled electrode holders or block electrodes.

The electrodes can be installed in the furnace bottom, in the lateral walls of the tank or inserted from the top, so-called top electrodes.

Appropriate positioning and wiring of the electrodes lead to reduced corrosion of the refractories and thus increase the furnace life. The most efficient concept is usually the usage of top electrodes. In case of a cold top furnace the batch is supplied by an area batch charger at an open side wall of the superstructure. This layer insulates the glass bath from the environment, making additional insulation unnecessary. The melting, refining and homogenising processes in all electric furnaces is in vertical direction.

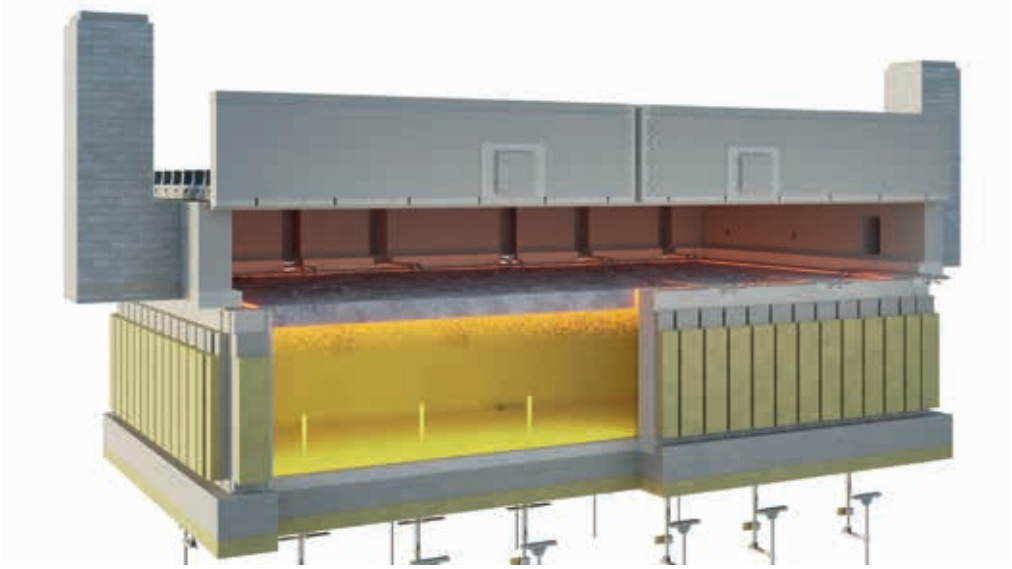
All electric furnaces are not controlled by temperature but rather by electric power and batch thickness. There is a very delicate balance between these two measures making the furnace less flexible in respect to pull changes. The flexibility can be improved by means of furnace design.

FEATURES

- **Low investment costs**
- **Low dusting, usage of simple bag filter system is possible**
- **Suitable for production of special glass with expensive, volatile and aggressive components in the batch**
- **No emissions due to firing (NOx, CO_2)**
- **Almost no SOx emissions**
- **Short time from glass to glass in case of brick to brick repair**

The specific pull is higher and not comparable with fossil fuel fired furnaces due to vertical melting process. The glass quality can be drastically higher than in a fossil fuel fired furnace. For this reason, high quality specialty glass, e.g. for optical application, is molten with all electric furnaces.

The energy consumption of all electric furnaces is lower than the one of fossil fuel fired furnaces. This is especially true for small furnaces, making small furnaces even more cost efficient. Increasing costs for CO_2 allowances can be a deciding factor for all electric furnaces despite higher costs for electric energy in the near future.



FLOAT GLASS FURNACES

GENERAL

Float glass furnaces are the largest type, both with regard to dimensions and to the overall melting output. These furnaces are close to the limit of constructive possibilities. Furnace capacities are usually between 600 – 800 t/d. Of course smaller units with 250 t/d are as possible as larger units up to 1200 t/d.

Float glass furnaces are especially designed for the production of soda lime glass. The requirements concerning glass quality are much stricter and differ from those of container glass.

DESCRIPTION

Float glass furnaces are usually cross fired furnaces. The regenerators, port necks and burners are arranged laterally. For each port neck there is a separate regenerator chamber together with a slide at the flue gas channel. This allows precise control of the furnace temperature over the entire length of the melting furnace. The firing is usually facilitated with underport burners. Oxyfuel burners installed in the sidewall near the charging zone are called zero-port boosting. This is a measure to increase melting capacity without enlarging the regenerator structure.

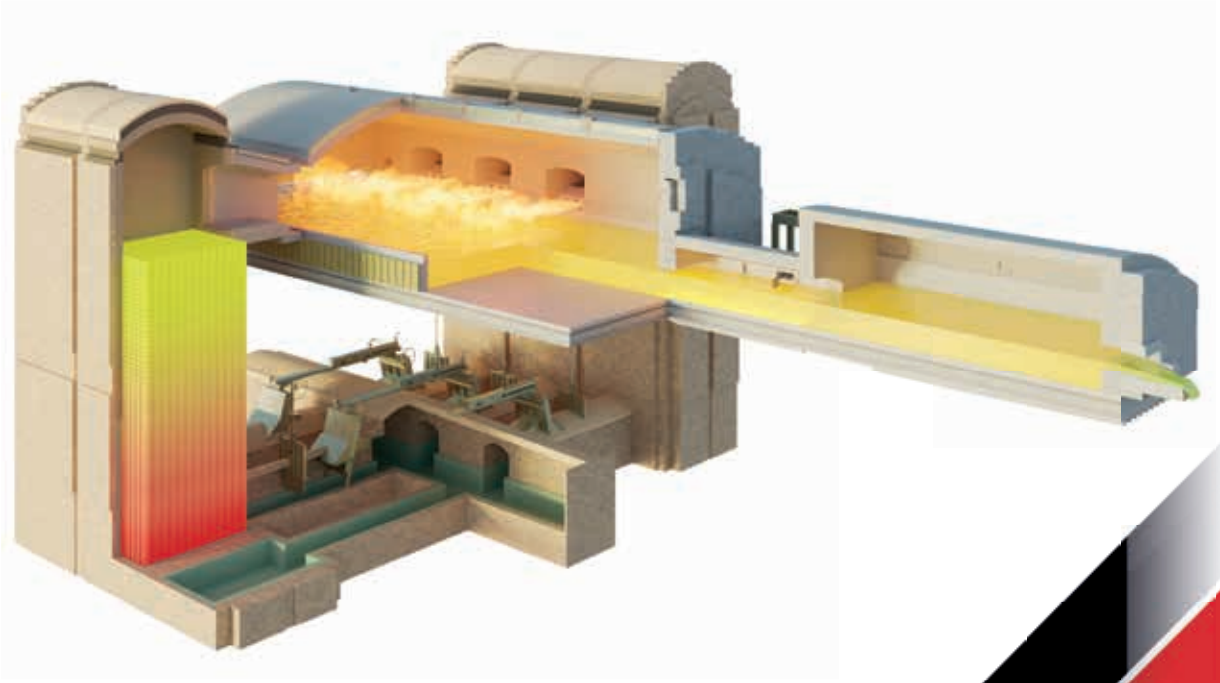
Float glass furnaces are constructed as open furnaces. A clear separation of the hot melting part and refining part and of the working end is not possible. This would lead to optical defects in the glass.

FEATURES

- **High furnace capacity up to 1200 t/d**
- **For high-quality glasses used as architectural glass or in the automotive industry**
- **Low energy consumption**
- **Long life**
- **Easy adjustable temperature profile**

Since the throat does not exist, it is merely one furnace which is very large. Instead of the throat there is a neck, where also coolers are installed, ensuring the perfect temperature for the subsequent float process. The float process itself starts, when the glass leaves the furnace at an overflow and entering the tin bath.

The adequate furnace insulation and optimal flow profile of the combustion air as well as efficient preheating of the combustion air allow the operation of the furnace with minimum energy consumption.



HYBRID FURNACES

GENERAL

Hybrid furnaces combine the combustion of a fuel (mostly natural gas) with a highly increased proportion of electric power. For the combustion, an end-fired as well as a cross-fired setup can be used. This includes furnaces with regenerators, recuperator and oxyfuel combustion. If the overall electric share is aimed to be over 40 to 50 %, the latter is the preferred solution. Compared to their classic pendant with little to no boosting, the overall energy consumption is reduced by approximately 5 to 10 %, while CO_2 emissions from combustion decrease 20 to 45 %.

DESCRIPTION

HORN® hybrid furnaces are specially designed to combine the classic heating method of combusting a fossil fuel with the usage of more electric power by using electrodes in the melting tank. The high electric share leads to a reduction of the fuel consumption and therefore to lower temperatures in the superstructure. In combination with a lower flue gas volume (even more for an oxyfuel furnace), this requires a modification of the superstructure design and possibly of the refractory materials to avoid cold spots and the subsequent damage.

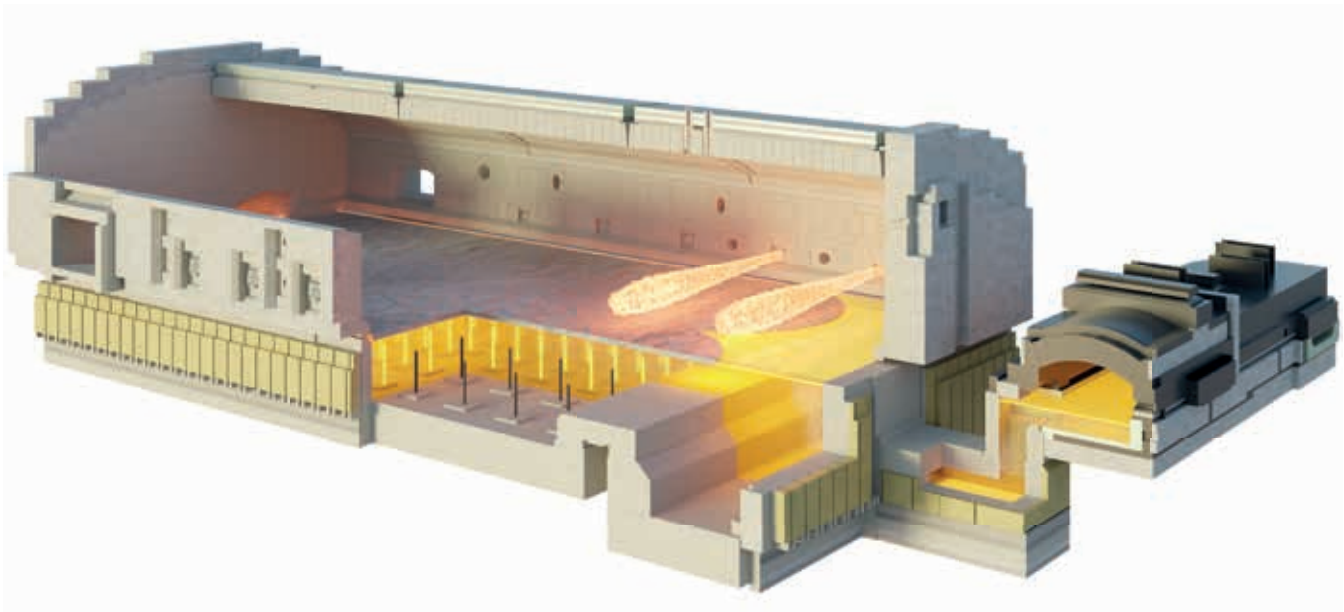
In the melting tank, a high number of electrodes are necessary. They can be installed as side or bottom electrodes depending on steelwork, position of burners, glass composition, etc. and preferably form “convection zones” in the tank. In these areas, the typical convection is preserved, despite the influence of all the electrodes, to support the melting process.

FEATURES

- **Low energy consumption**
- **Low emission values**
- **Reduced NOx emissions**
- **Low investment cost for flue gas equipment due to low flue gas volume**
- **Easy adjustable temperature profile**
- **High flexibility during load change**
- **Flexibility regarding energy (fossil <-> electric)**
- **High specific melting output**

To some degree, a hybrid setup offers flexibility regarding the energy contribution between fossil and electric and also for the pull rate.

Currently hybrid concepts are used for furnaces with smaller pullout of 50 to 400 t/d and/or specialty glass, but in general the maximum furnace size is approximately the same as for the classic fossil furnaces (750 t/d and even larger).



HORN® EQUIPMENT (FOR GLASS MELTING FURNACES)

HORN®'s extensive expertise in all fields of glass melting technology is shown in the supply of equipment which is innovative and state-of-the-art technology. The special HORN® design and know-how for the equipment makes it possible to offer customers tailor-made solutions engineered in Germany.

HORN® supplies both different types of furnaces and various equipment for glass melting furnaces to increase capacity, e.g. barrier boosting, melting boosting, throat boosting, bubbling systems or oxyboosting. Customers get exactly the equipment which is specially tailored to their individual needs to ensure a smooth production process:

Combustion System & Burners

Electrical Equipment

Batch Chargers

Bubbling System

Reversing Unit

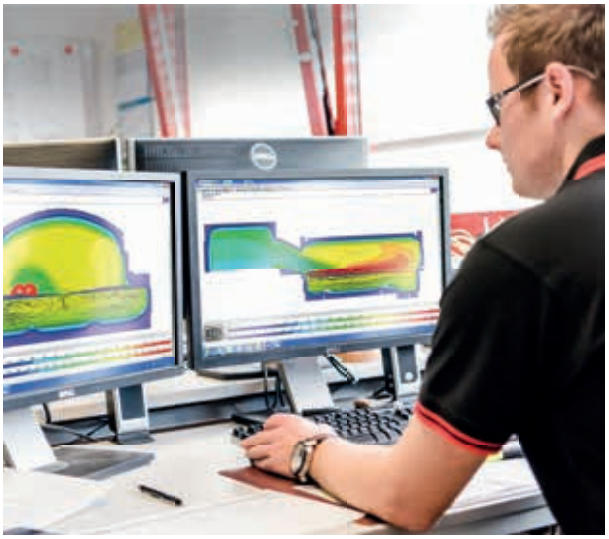
e-Fusion
HORN POWER BOOSTING

RESEARCH AND DEVELOPMENT

In an economic system, research and development has always been one of the driving growth factors. Even in the highly conservative glass industry, research and development is indispensable. Due to the rapid development of IT technology as well as measurement and control technology, it is now possible to go further.

The corporate success of HORN® Glass Industries AG is also based on the systematic further development of existing technologies and processes. At the Plössberg site, teams from different departments work on the conception and implementation of innovative solutions.
In keeping with the open innovation approach, the HORN® research and development department, or R&D for short, works in close cooperation with the specialist departments, production and commissioning department. Cooperations with international partners, university institutes, universities of applied sciences, research institutes and many national and international customers round off the R&D network and enable HORN® to respond directly to customer interests.

The aim of the R&D department at HORN® is to design and use plant components and the materials used even more efficiently and customer-friendly. The focus is not only on customer orientation, but also on the ecological aspects, which have been implemented, for example, in the optimisation of the "GCS® 301-advanced" series feeders in sizes K36-K54. The better insulation of the channel blocks and the more compact, modular design of the feeder result in a reduction of wall losses due to this optimisation, which is reflected in a higher thermal homogeneity as well as a lower specific energy input. The superstructure has been standardised, which has a cost-saving effect in production.



Various stages are necessary before a project can be fully implemented commercially in the plants. These stages are generally divided into the search for new knowledge and needs, planning, organisation and control.

The use of the latest tools such as modelling programmes, CAD programmes, HORN®-specific conception and calculation software as well as high-precision manufacturing techniques speed up the process of new developments or optimisation of plant components, technological procedures as well as entire glass units. As a further example, a new type of burner bracket was developed within a very short time, which can be mechanically adjusted both horizontally and vertically at an angle to the furnace axis without having to remove the burner from the bracket. This bracket considerably simplifies the interval maintenance work of the furnace personnel and facilitates furnace optimisation with regard to pollutant emissions (NOx, CO).

In addition to this equipment, a stereo and a polarisation microscope with digital evaluation possibilities are available. In conjunction with other analytical methods of our national and international laboratory partners, these help to identify and reduce customer-specific glass problems such as inclusions, streaks, gisps, bubbles, etc.

HORN GLASS INDUSTRIES

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