The future we see through

CONDITIONING WORKING END FOREHEARTH

COMBUSTION AND COOLING
STIRRER
EQUIPMENT
FOREHEARTHS
THERMAL MAPS

BDF® industries

OUR HERITAGE

Since 1906, BDF Industries' principal activity has been the development and integration of complex technologies to aid industrial progress.

The **worldwide market** depends on BDF's multitasking, multicultural, and multi-expertise strategy, which has evolved and shaped itself over the years in response to market demands.

BDF provides the chance to join a top-notch technological group ready to compete with present and future business opportunities in terms of **competitiveness, performances, and reliability of products** and processes thanks to its natural collaborative instinct and the professionalism shown in more than **115 years of tradition**.

The future we see through.

OUR MISSION

Manufacturer of cutting-edge machinery, BDF Industries is a group where innovation and performance converge in a never-ending quest for excellence.

MELTING

For the design and supply of furnaces, working ends, and forehearths, BDF Industries Melting's product portfolio comprises the whole glass melting and conditioning technologies. Additionally, **relevant equipment** including oil and gas burners, firing system air, exhaust reverse valves, batch chargers, and stirrers are part of the product line.

BDF Industries furnaces are engineered with an **high level of customization**, focusing in particular on energy efficiency and environmental impacts. BDF Industries is able to offer a wide range in **design, manufacture, and supply** of different furnace types for production of containers, tableware, lighting ware, and technical glassware due to a long history of experience combined with a team of skilled people who work together in a synergistic way..

FORMING

The glass container Forming product line of BDF Industries is the company's historical primary activity. BDF Industries can supply a wide range of **machines with a high level of production flexibility** to satisfy the needs of its customers.

With more than 65 years of experience in glass forming field, BDF Industries can offer a complete range of IS machine including gob forming and delivery, ware handling, container and variable equipment. The glass forming machineries are **fully designed and assembled** in house at BDF Industries **in Italy**, which has relevant knowledge of production process with the most important glass manufacturers in the world (e.g. strong credentials for forming business in O-I, Saverglass, Sisecam, Vetropack, Vitro...).

SERVICE

BDF Industries has a Service division dedicated to provide a comprehensive range of **high-quality service solutions** to our clients from a single source. From glass melting to forming, filtering, energy facilities, and automation, our services serve the whole product value chain.

The service product line includes installation & startup, upgrades of mechanical equipment and automation, technical assistance for repairing and overhauling, training, performance evaluation & long term service agreement, integrated maintenance management & diagnostic solutions and systems, spare parts.

The contents of service are the following:

- Supply local qualified supervisors
- Supply of certified end/or upgraded OEM (Original Equipment Manufacturer) spare parts for all maintenance operations
- Performance of all equipment maintenance
- Repairs using state-of-the-art technology
- Optimization of Spare Parts inventory
- On the job Training of local maintenance and operation personel.

The BDF Industries Learning Center in Italy, as well as strategically situated Service Centers, provide a comprehensive range of technical training. Our technical courses are taught by field-tested experts who combine theoretical knowledge with practical expertise.

WORKING END & FOREHEARTHS

The BDF Working End and Forehearth idea is based on the well-proven and widely acknowledged assumption that glass conditioning begins at the furnace exit.

The forming process requires to be fed with glass on a viscosity range that is normally much different from the one we find at the furnace exit.

The Working End and Forehearths in the container plants must cool the glass due to the exit furnace temperature being substantially greater than what is required to provide the proper glass viscosity for the forming process.

The glass is a material that can not be strongly cooled, therefore the cooling process to be applied must be designed taking into account a number of variables such as the thermal balance, the glass colour, the path, the “head loss”.

We must also consider the chemical aspect, as the characteristics of the atmosphere with which the glass is in contact can alter its quality.

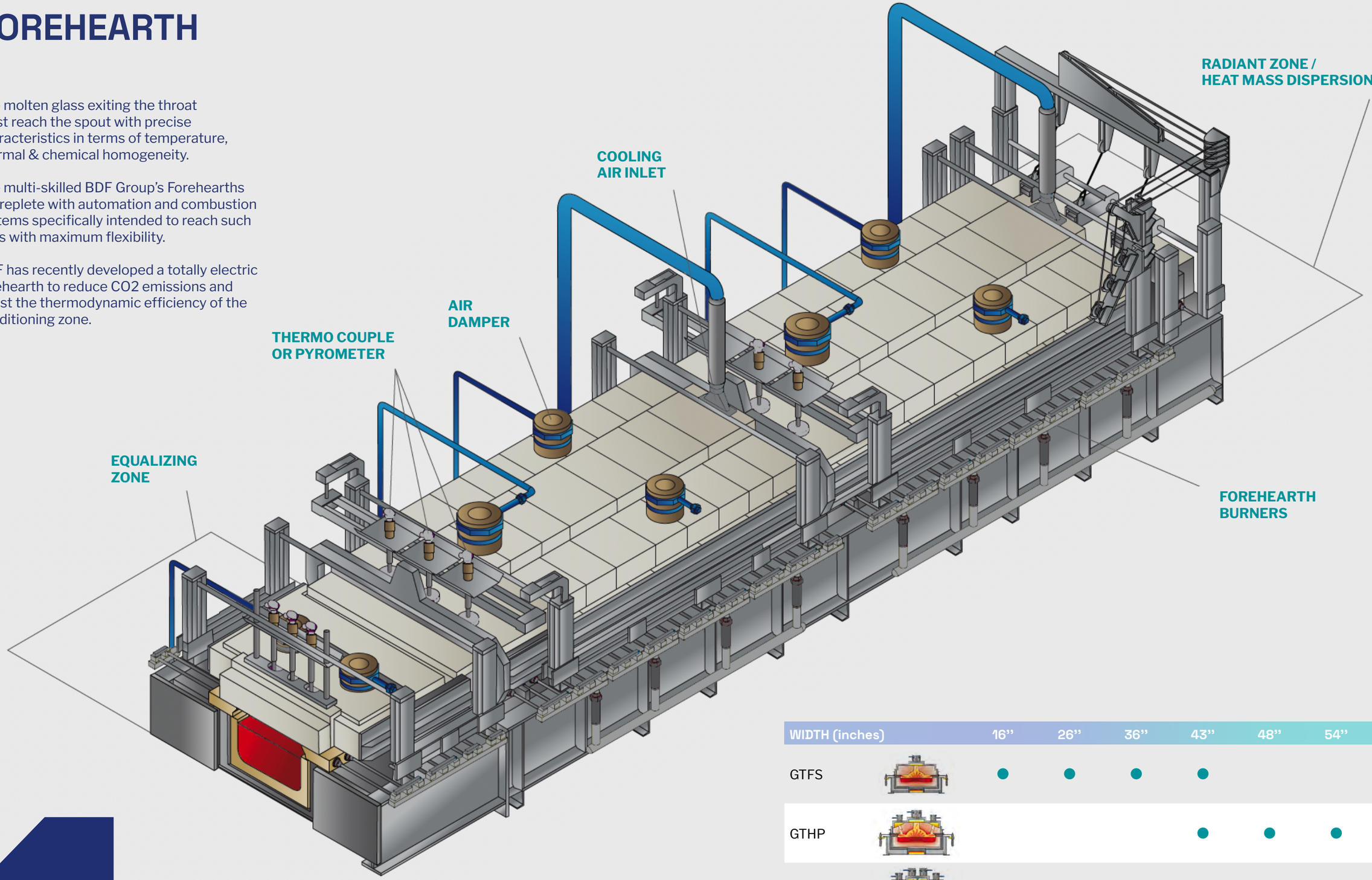
“Conditioning” refers to the process of cooling glass that occurs after the furnace throat through the distributor and forehearths. Conditioning affects every step of the way from the throat to the spout entry, not just the forehearth.

FOREHEARTH

The molten glass exiting the throat must reach the spout with precise characteristics in terms of temperature, thermal & chemical homogeneity.

The multi-skilled BDF Group's Forehearths are replete with automation and combustion systems specifically intended to reach such aims with maximum flexibility.

BDF has recently developed a totally electric forehearth to reduce CO2 emissions and boost the thermodynamic efficiency of the conditioning zone.



NNPB Ready

WIDTH (inches)		16''	26''	36''	43''	48''	54''	60''
GTFS		●	●	●	●			
GTHP					●	●	●	●
GTHP 4C						●	●	●
PULL (data are only approximate)		5-20	20-45	40-75	70-100	90-145	115-180	150-230

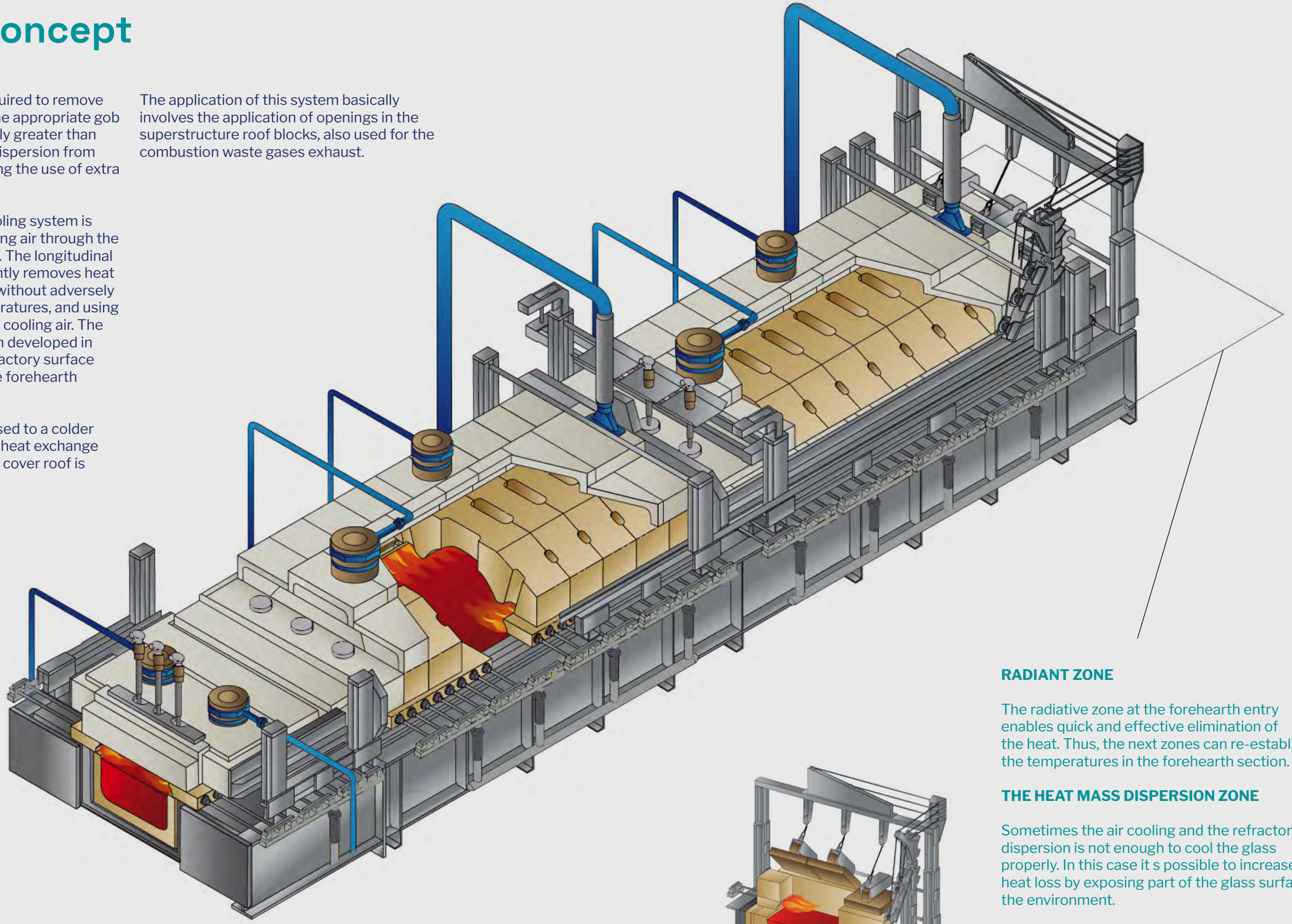
Cooling Concept

Very often, the energy required to remove from the glass to supply the appropriate gob temperature is substantially greater than what can be achieved by dispersion from the refractory, necessitating the use of extra cooling.

The forced convection cooling system is based on introducing cooling air through the forehearth superstructure. The longitudinal centre line cooling, efficiently removes heat from the hot centre glass without adversely affecting side glass temperatures, and using relatively small volumes of cooling air. The cover roof design has been developed in order to maximize the refractory surface exposed to the glass in the forehearth centre.

Because the glass is exposed to a colder big refractory surface, the heat exchange between the glass and the cover roof is increased.

The application of this system basically involves the application of openings in the superstructure roof blocks, also used for the combustion waste gases exhaust.



NNPB
Ready

RADIANT ZONE

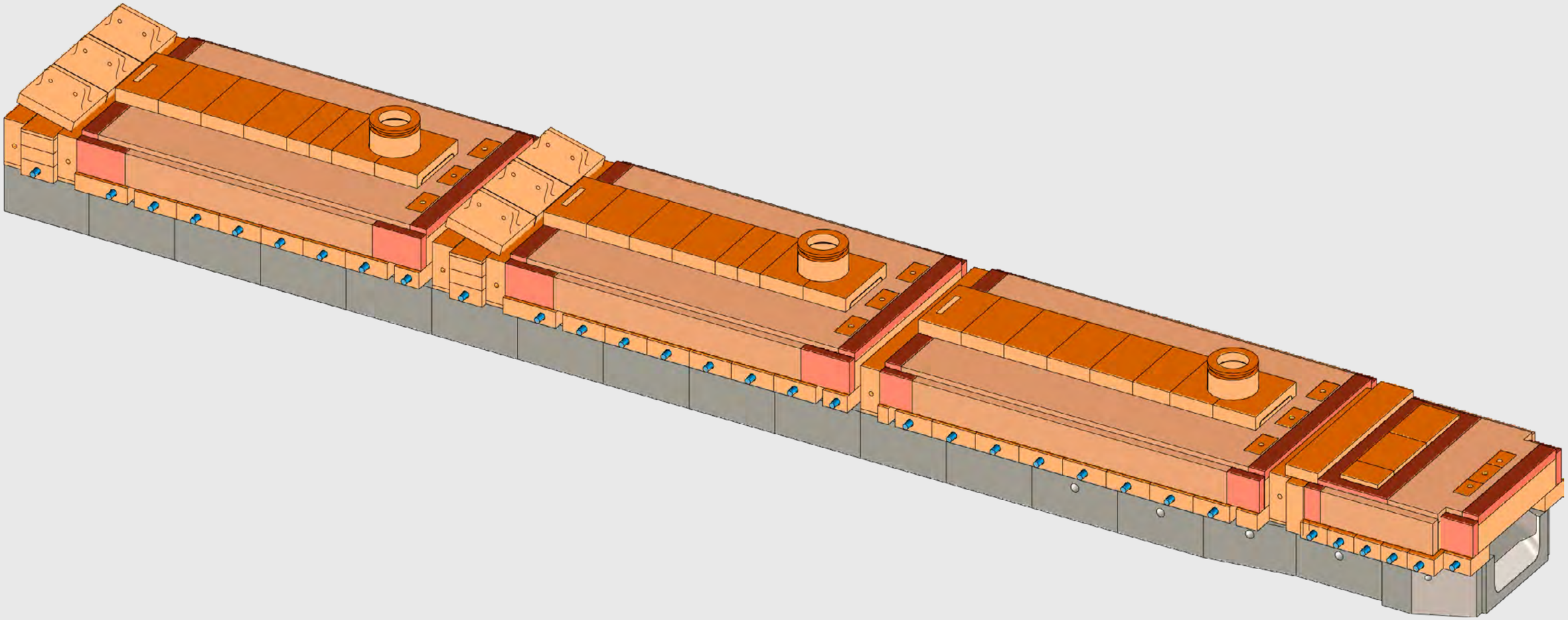
The radiative zone at the forehearth entry enables quick and effective elimination of the heat. Thus, the next zones can re-establish the temperatures in the forehearth section.

THE HEAT MASS DISPERSION ZONE

Sometimes the air cooling and the refractory dispersion is not enough to cool the glass properly. In this case it s possible to increase the heat loss by exposing part of the glass surface to the environment.

The heat mass dispersion zone is normally installed at the forehearth entry, where the glass temperature is higher and the heat loss is more efficient.

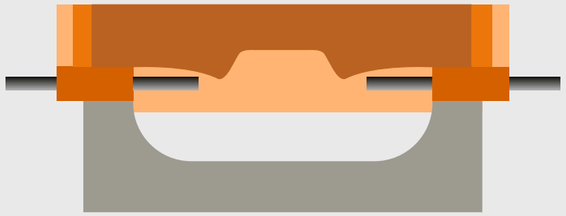
ELECTRIC FOREHEARTH



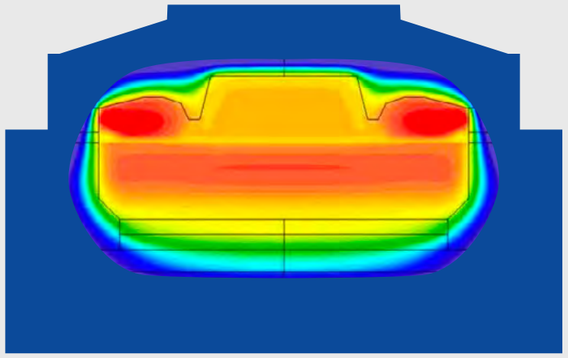
BDF has recently developed a totally electric forehearth to reduce CO2 emissions and boost the thermodynamic efficiency of the conditioning zone.

The replacement of the pencil burner flame with a radiative element that provides the same amount of energy to the glass but with more than three times the time efficiency is unique to BDF electrical heating glass conditioning philosophy. The heat transmission from the flame ELECTRIC FOREHEARTH to the glass occurs through radiation, however a significant amount of energy is lost due to heat in the exhaust that is neither collected or recuperated.

The electrical heating element technology allows for the transmission of energy to the glass by radiation without any exhaust and, thus, without the associated losses (see also a cfd simulation of a similar project) will be lost by heat in the exhaust that is neither collected or recuperated.



Section of Heating System



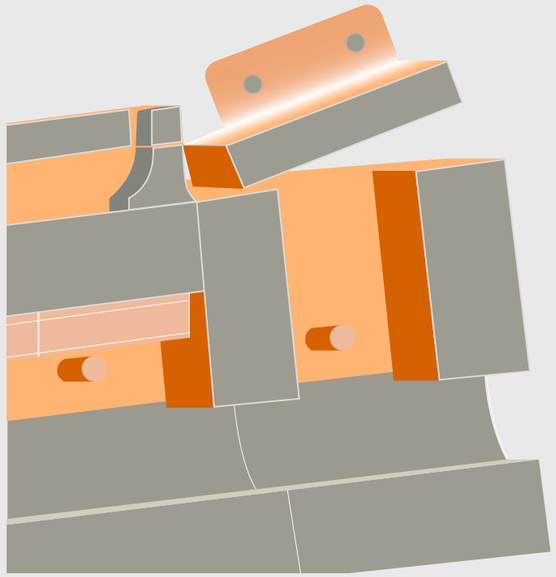
CFD of BDF Electric Forehearth

If necessary, it is always possible to use submerged electrodes in contact with the glass, particularly for dark glasses, to increase thermal homogeneity in the equalizing zone. The electrical power to the heating elements is automatically controlled by a scr power module powered by a pid regulator, based on the temperature setting.

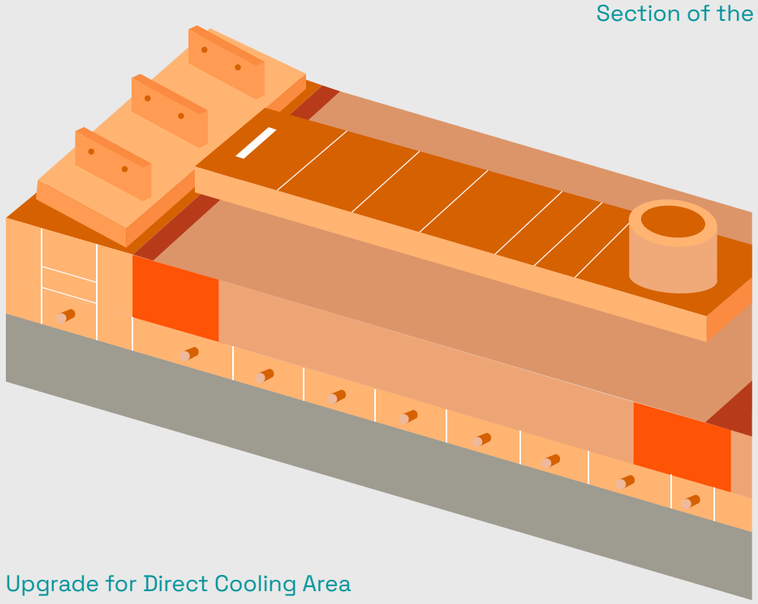
In addition to the electrical heating system, a cooling system must be built for optimal glass conditioning.

Indirect cooling type in combination with the radiative zone (or massive heat dispersive zone) are the cooling solution toachieve the result: it means that no direct air goes in contact with the glass surface.

The radiative zones work in an efficient way and with even thermal dispersion when the glass temperature, especially at the entrance of forehearth, is still high. It is also likely that a solution with three tiles (items) will be offered in order to balance the cooling impact between the sides and the middle. The tiles open/close regulating system is manually operated with the possibility to make it automatic in a second stage using a pneumatic actuator to move each tile individually:

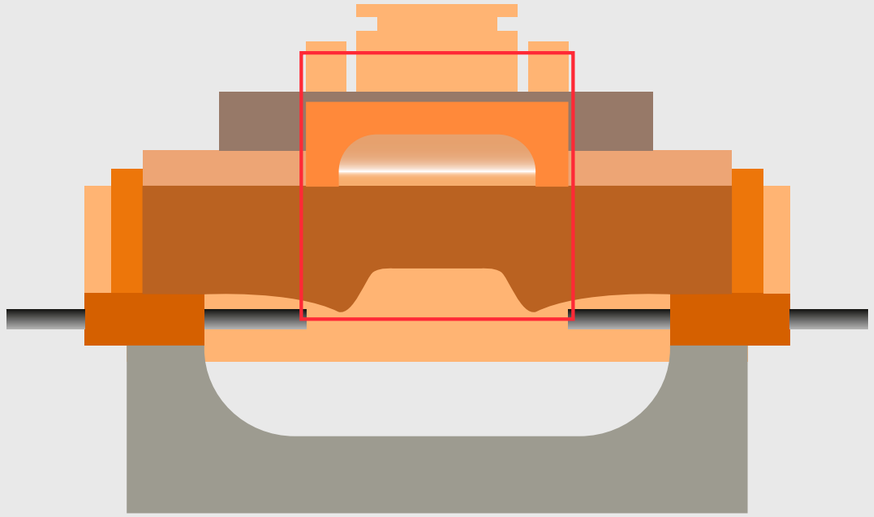


Section of the Radiating Zone



Upgrade for Direct Cooling Area

Consequently, indirect cooling (with the option of moving it in conjunction with partially direct cooling) enables fine temperature conditioning:



Indirect Cooling Shape Section

The frequency controlled fan motor automatically maintains the stability of the cooling air pressure to the centralized cooling station. The air flow regulation for each cooling zone is automatically operated by a servomotor powered by the control system's pid regulator.

Temperature is measured using single-level thermocouples in the cooling zones and three tri-level thermocouples in the equalizing zones. This thermocouple configuration produces a 9-point grid measurement, which provides a matrix for determining the thermal homogeneity of the glass in this area. Temperature is controlled by varying the energy intake.

The redundant software control system for the furnace and glass conditioning system will execute the control functions. Please see the image below as an example.

COMBUSTION & COOLING

COMBUSTION AND COOLING AIR

To supply the correct volume of cooling and combustion air to the forehearth, only one blower is used, with significant saving in terms of investment costs and operating costs.

The system is preassembled in one unit, it contains the necessary number of operating fans and fans in stand-by and it is equipped with adequate absorbent support and filters.

COMBUSTION & COOLING CONTROL UNIT

The rack is designed to control the gas-air mix, the cooling air and the damper air pressure, for each forehearths zones, by fully automated gas and air regulating valves.

- It is designed to keep the air/gas ratio steady
- Cooling and heating are grouped in one rack only
- Linear regulation valves are used to vary the flow according to valve opening
- Critical components for good forehearth management are pre-assembled and installed in a dedicated unit, usually positioned in an area less exposed to the heat coming from forehearths and w/e.

COMBUSTION & COOLING
UNITS

To control the heating and the cooling BDF provides a unit which is normally supplied preassembled and ready to be installed.

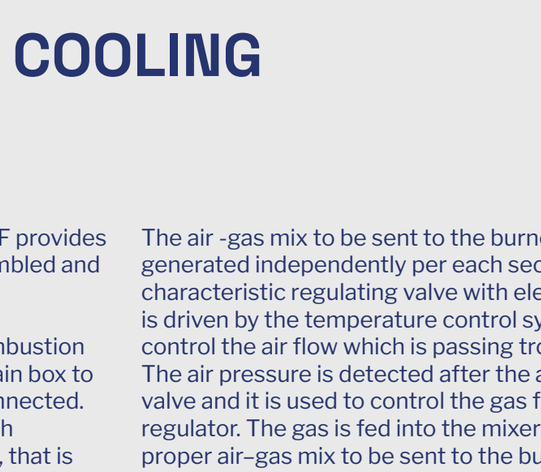
The same ventilators are used for the combustion and for the cooling. The air is fed into a main box to which the heating–cooling section are connected. The burners are installed on the forehearth sides, and they are fed with an air-gas mix, that is introduced in the room over the glass and that burns thanks to the ambient high temperature. The air-gas mix ratio must be kept constant, since any change compared to the optimal value could cause defects (most of all seeds and blisters).

This can be achieved by regulating the gas flow rate depending on the air flow rate, whose valve is operated by the control system. Each cooling and equalizing zone is equipped with an independent group feeding the burners. The temperature control system regulates the opening of the air valve depending on the value detected by the temperature sensor (optical pyrometer or thermocouple), independently on each zone.

The air -gas mix to be sent to the burners is generated independently per each section. A linear characteristic regulating valve with electric actuator is driven by the temperature control system to control the air flow which is passing trough a mixer. The air pressure is detected after the air regulating valve and it is used to control the gas flow by a gas regulator. The gas is fed into the mixer to achieve a proper air–gas mix to be sent to the burners.

The system is designed to assure a constant air–gas ratio in a range of 1 to 10 in terms of supplied energy. The cooling air flow is controlled independently per each section by a butterfly valve with electric actuator driven by the temperature control system.

The same actuator drives the air to be sent to the air damper to control the pressure into the forehearth superstructure in order to avoid fresh air infiltration through the chimney when the cooling is working at low capacity.



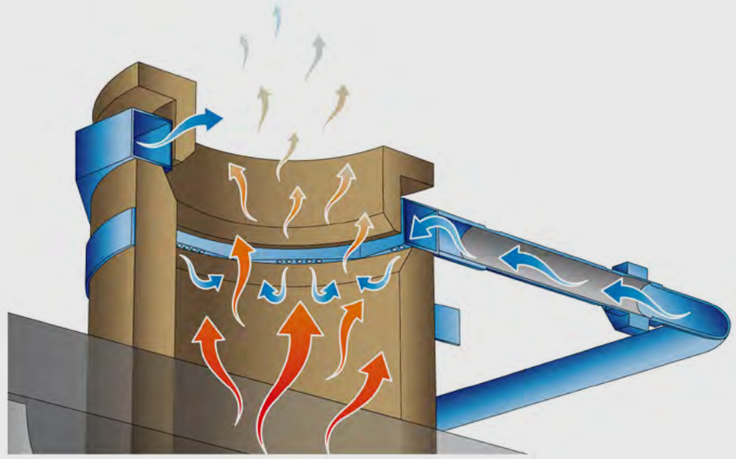
COMBUSTION ROOF BLOCK COOLING

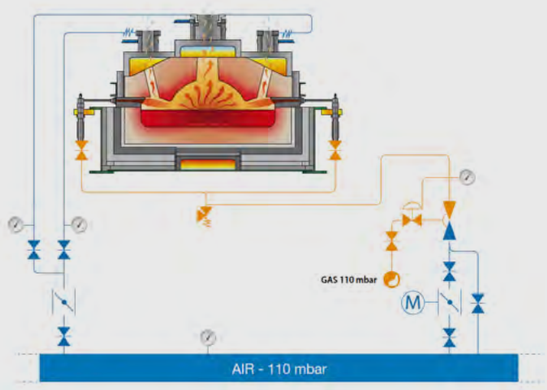
A tiny refractory channel running parallel to the foreheart axis is installed over the superstructure. The upper surface of the roof block is cooled when cooling air is blasted via this duct. This reduces the temperature of the lower surface of the tile and energy is removed from the glass bath by radiative heat transfer to the cooled tile. The cooling air travels in the direction of the glass flow and is exhausted, together with the combustion gases, through the centrally located cooling air exhaust.
The volume of the cooling air blown along the channel is adjusted to vary the cooling effect, that is controlled by the flow regulation of the cooling air stream. The automatic control system will control heating and cooling functions within each independent zone.

AIR DAMPER
SYSTEM

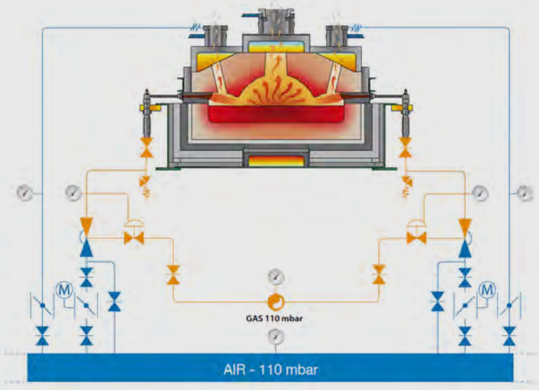
All exhausts are fitted with automatically controlled air dampers. The air damper is made of a series of internal concentric air jets creating an air curtain which is controlled to allow either cooling air enter into the superstructure or products of combustion to exhaust from the forehearth, depending on whether they act as a cooling air inlet or flue.
Air dampers represent an effective means of controlling forehearth pressure without the use on any moving parts, hence minimizing maintenance requirements.

The amount of cooling air entering the cooling channel and the position of the dampers are automatically regulated according to the cooling requirement of the forehearth.
The same actuator, that controls the cooling air flow, drives the air to be sent to the air damper to control the pressure into the forehearth superstructure in order to avoid fresh air infiltration through the chimney when the cooling is working at low capacity.





STANDARD COMBUSTION



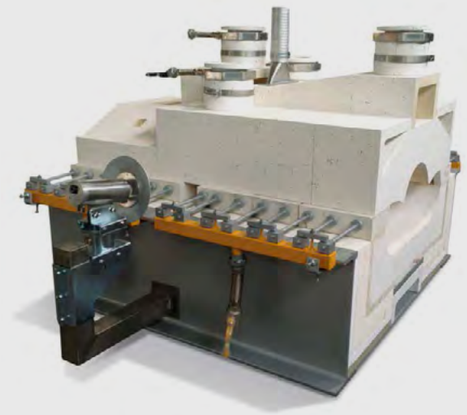
SIDE-BY-SIDE COMBUSTION
(if required)

EQUIPMENT

- Forehearth burner
- Eagle 3.1 - glass level
- Pneumatic - glass level
- Stirrer
- Measurement
- Working-end & forehearth control system
- Thermal map

EAGLE 3.1 GLASS LEVEL MEASUREMENT SYSTEM

- No object in contact with glass or in the combustion chamber
- Nothing in movement
- Absolute level measure
- Easy to install
- Protective air curtain against dust
- Maintenance-free
- Self-calibrating
- Vibration proof

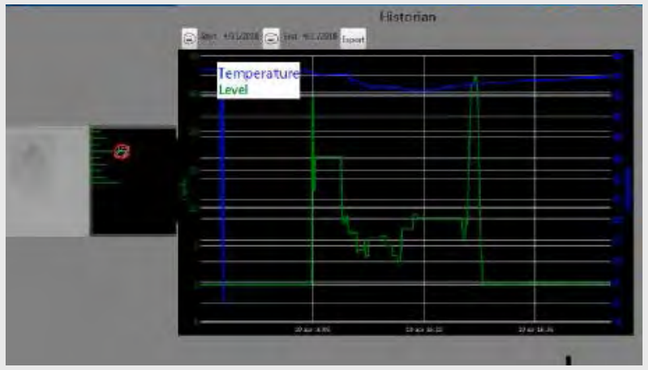


The new Generation Glass Level Measurement system. The EAGLe 3.1 “Enhanced Absolute Glass Level” (Patented) system measures the glass level by the optical reflection of a fixed pointer located away from the glass or the burner reflection. E.A.G.Le 2.0 and 3.0 have undergone an innovative and technological evolution: the new release 3.1 offers new features and improvements in measurement and performance.

EAGLe 3.1 is composed of video camera placed in a rigid industrial casing and mounted at approx. 50 cm from the measurement point using a small hole (50x50 mm) in the furnace working end. A new protective air curtain is designed in order to avoid the possible dust coming out from the small hole. All the parameters of calibration and tuning can be read and set from whatever PC (Personal Computer) only one cable for data collection and power.

EAGLe 3.1 acquires and processes the images through advanced algorithms controlled by a system of Artificial Vision in an industrial computer equipped of a touch screen operator panel. The real pointer- reflected image or the burner reflection are acquired at high frequency enabling thus to establish the actual level of glass with absolute precision higher than ±0.01mm. EAGLe 3.1 is self-calibrating and vibration-proof. EAGLe 3.1, thanks to the characteristics described, is the most advanced glass level measuring device present on the market.

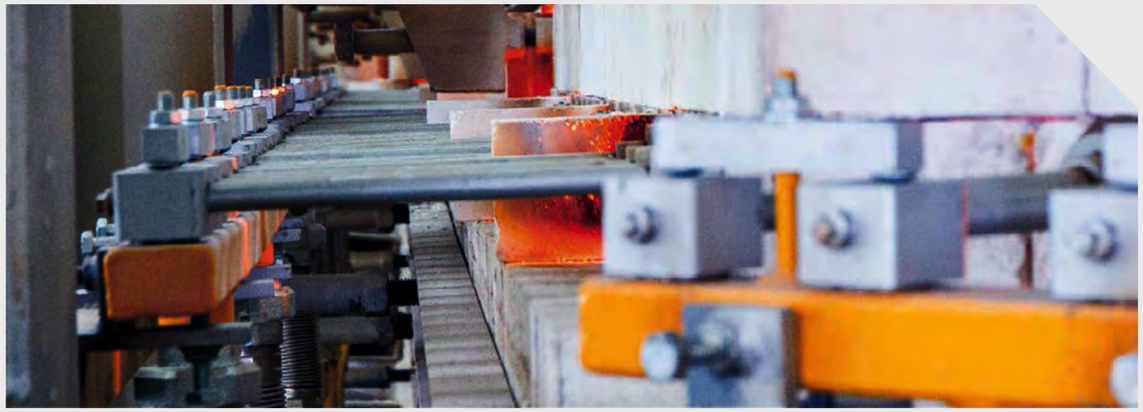
Eagle 3.1 Supervision control system
Standard user-friendly supervision in operation



BURNERS

The burners are positioned on the forehearth sides and are fed with an air-gas mixture that is delivered into the room over the glass and burns due to the high ambient temperature. The air-gas mix ratio must be kept constant since any deviation from the appropriate value can result in defects (mostly seeds and blisters).

Each nozzle has a working area calculated on the basis of the energy required in each zone, according to the outcome of the thermal balance calculation. In order to prevent any possible damage in case of backfiring, safety heads are installed, which purpose is to open in case the operating pressure exceeds the normal values.



STIRRER

With the BDF stirrer mechanisms it is possible to achieve better quality in glass homogenization and better production flexibility of coloring forehearths.

The system consists of a steel structure and a couple of mixing units typically installed on forehearths equalizing zone.
The mixing units, made of refractory material, are drawn with special profile, apt to improve the glass temperature homogeneity and thus contributing to reduce any possible defect, such as the “cat scratches”, by mixing mechanically the Zirconium in the molten glass.

- Sliding bracket motion for easy maintenance or refractory parts replacement
- Different configuration up to 4 stirrers
- Independent rotation for left/right 4-stirrer group
- Same rotation or counter rotation for each stirrer
- Remote electronic control for speed and direction

SCADA SOFTWARE

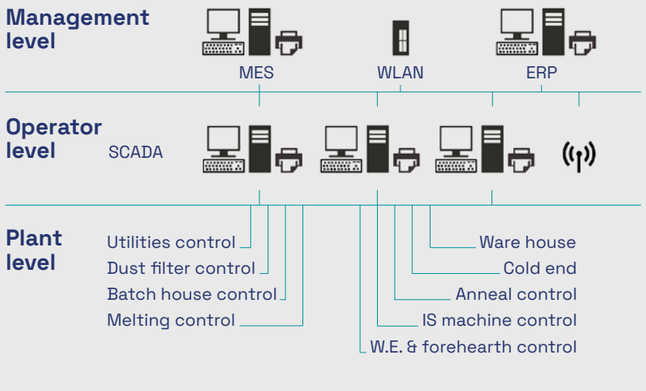
Since BDF SCADA is built on IgnitionTM, it is fully accessible to various devices, including smartphones and tablets.

User management and trend control is really simple and reliable and very useful for diagnostic in plant or by remote.

BDF also propose a Data collecting Historian product called PANORAMA. PANORAMA is oriented to fulfill all the requirements of the Industry 4.0 giving our customer the possibility to concentrate and synchronize all the BDF equipment in a single historian archive, to manage and edit report, to redirect and manage alarms (even to SMS or mail) and possibly to add manual entry (as Pull or Pack to Melt) for statistical reason.

Control cabinet

GENERAL PROCESS CONTROL ARCHITECTURE



Control systems focused on key- performance factors to grant:

- Minimum Energy Consumption and Operation Cost
- Glass Quality
- Low Polluting Emission
- Furnace Life-Time
- Reliability elaboration of Trend Process

The System allows effective, reliable control and recording of real time or historical data during the whole furnace campaign.

Continuous monitoring and control of parameters such as:

- Pilot Temperatures
- Combustion
- Electric Energy and Energy Consumption

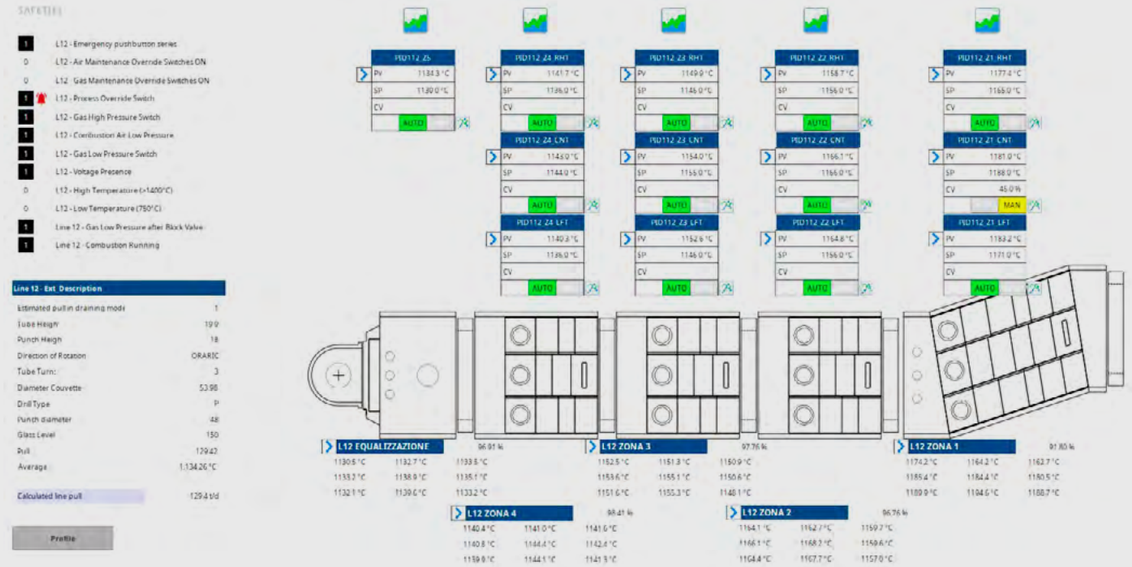
Flexible application:

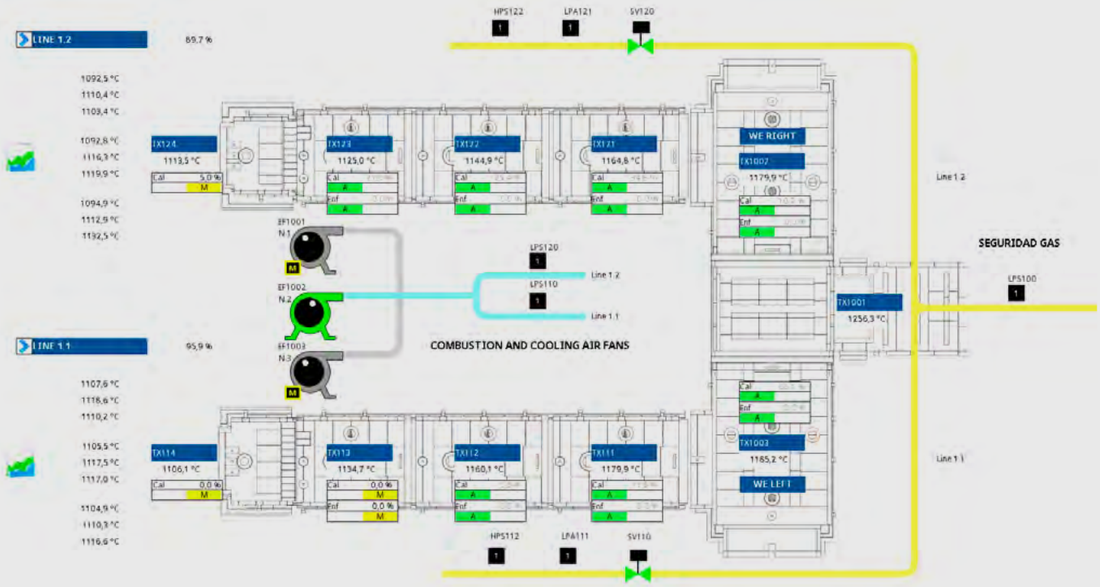
- Full supply or integration with most best-known PLC brands.
- Integration with glass plant Supervision via SCADA system (Supervisory and Data Acquisition).

The application of a SCADA acquisition system creates a multi-terminal network for a fast access to required information and grants a constant overview of:

- Process
- Centralized Controls
- Historical
- Trend
- Correlation between different areas of the plant process.

Access from different places and with hierarchies levels is available to ensure a proper flexibility and safety managing.





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