CENTAURO

Centauro

the new reality for glass furnace advanced heat recovery

STARA GLASS

The state of the art of gas / air fired glass furnaces

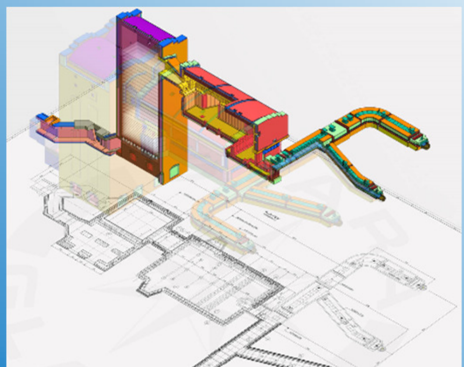
Regenerative (End Port) Furnaces

Furnaces where waste gas and combustion air alternatively use the same path, releasing and getting heat from the refractories they contact.

Benefits:
- Significantly lower consumption

Limits:
- Vertical space requirements
- Working discontinuity

Combustion air thermal recovery:
- 1100 – 1300°C
- Waste gas heat recovery: ≈ 65%



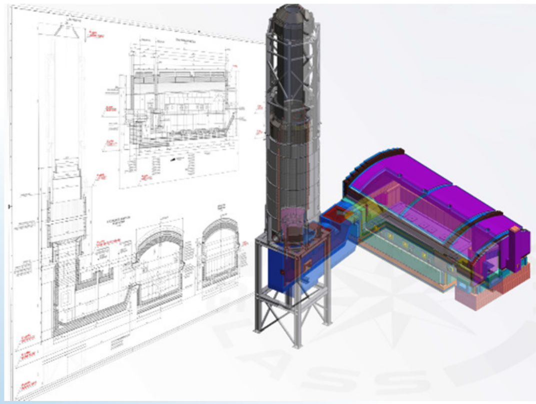
Recuperative (Unit Melter) Furnaces

Furnaces where waste gas and combustion air continuously pass through separate paths, directly exchanging heat through the separating metallic surfaces.

Benefits:
- Lower earlier investments
- Working continuity

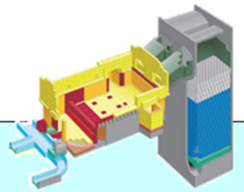
Limits:
- High consumption (temperature limit of combustion air due to metal technological limits)

Combustion air thermal recovery :
- 500 – 800°C
- Waste gas heat recovery: ≈ 40%



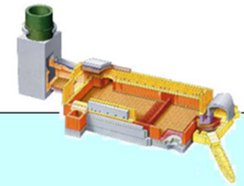
Heat balance – regenerative / recuperative systems

Furnace	Regenerative			
Input heat	*kcal/kg*	*MJ/ton*	*Gcal/h*	*%*
Fuel	990	4143,70	9,48	94
Electrical power	54	225,43	0,52	5
Air	10	40,49	0,09	1
Total input heat	***1053***	***4409,61***	***10,09***	***100***
Output heat	*kcal/kg*	*GJ/ton*	*Gcal/h*	*%*
Glass	447	1872,95	4,29	42
Chemical reactions	105	437,97	1,00	10
H2O evaporation	21	86,02	0,20	2
Waste gas and air leak	314	1313,59	3,01	30
Holes and waste gas leak	10	43,76	0,10	1
Thermal loss	157	655,31	1,50	15
Total output heat	***1053***	***4409,61***	***10,09***	***100***
Furnace data				
Pull [t/day]	**230**			
Pull [kg/h]	9583			
Fuel [Sm3/h]	**1157**			
Electrical power [kW]	**600**			
H2O %	3,0			
Cullet %	**30**			
Specific consumption [kcal/kg]	***1043 ± 3%***			
Cost [k€/Year]	***3565 ± 3%***			



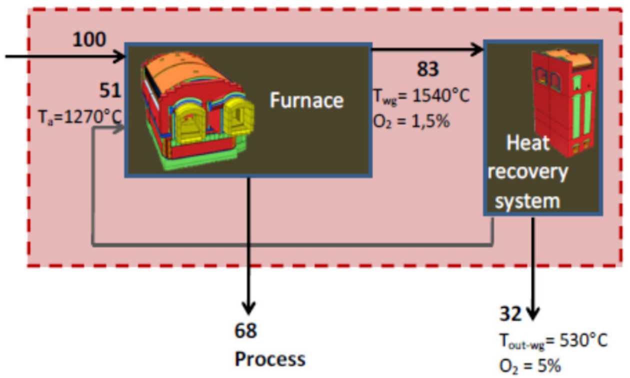
In order to produce the glass type, at the same pull, a recuperative furnace has fuel consumption about 30-35% higher than a regenerative one.

Furnace	Recuperative			
Input heat	*kcal/kg*	*MJ/ton*	*Gcal/h*	*%*
Fuel	1357	5682,85	13,01	95
Electrical power	54	225,43	0,52	4
Air	12	52,08	0,12	1
Total input heat	***1424***	***5960,35***	***13,64***	***100***
Output heat	*kcal/kg*	*GJ/ton*	*Gcal/h*	*%*
Glass	447	1872,95	4,29	31
Chemical reactions	105	437,97	1,00	7
H2O evaporation	21	86,02	0,20	1
Waste gas and air leak	649	2715,42	6,22	46
Holes and waste gas leak	6	26,67	0,06	0
Thermal loss	196	821,32	1,88	14
Total output heat	***1424***	***5960,35***	***13,64***	***100***
Furnace data				
Pull [t/day]	**230**			
Pull [kg/h]	9583			
Fuel [Sm3/h]	**1586**			
Electrical power [kW]	**600**			
H2O %	3,0			
Cullet %	**30**			
Specific consumption [kcal/kg]	***1411 ± 3%***			
Cost [k€/Year]	***4695 ± 3%***			



End Port furnace

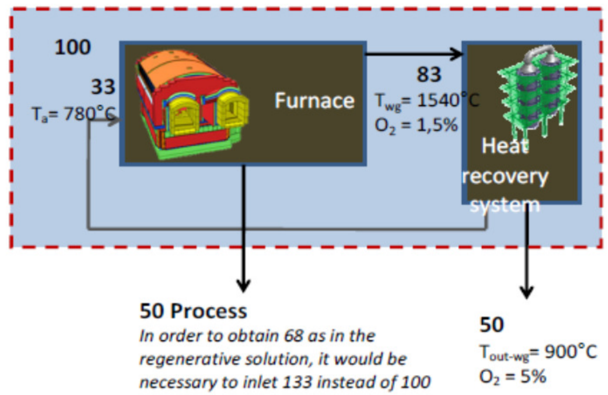
ηchambers = 0.61
ηfurnace = 0.68



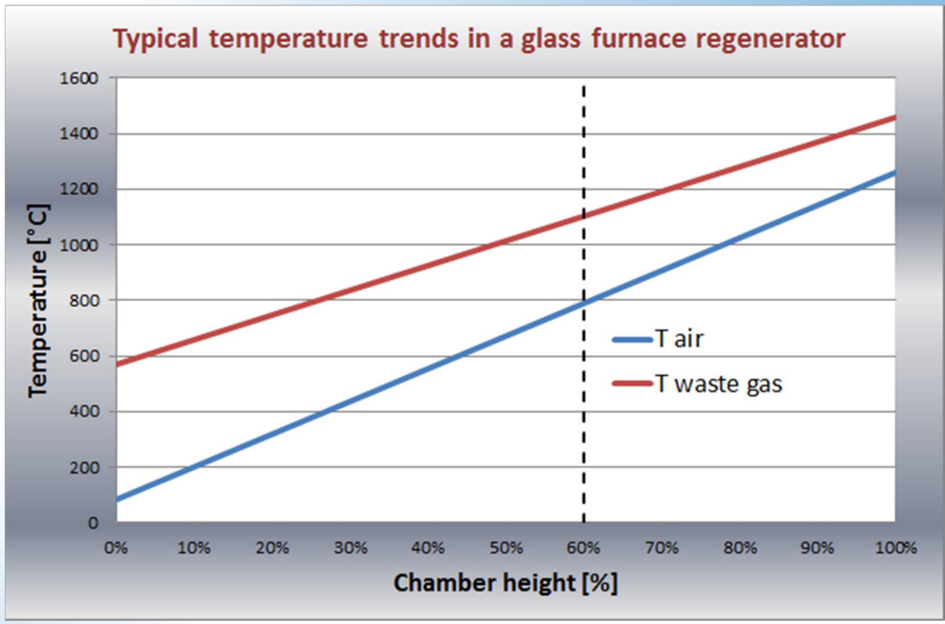
Unit Melter (recuperative) furnace performance is strongly penalized by high waste gas exit temperature, about 400°C higher than in regenerative furnaces, and by preheated air temperature, about 500°C lower.

Unit Melter furnace

ηrec = 0.40
ηfurnace = 0.50



The idea of Centauro

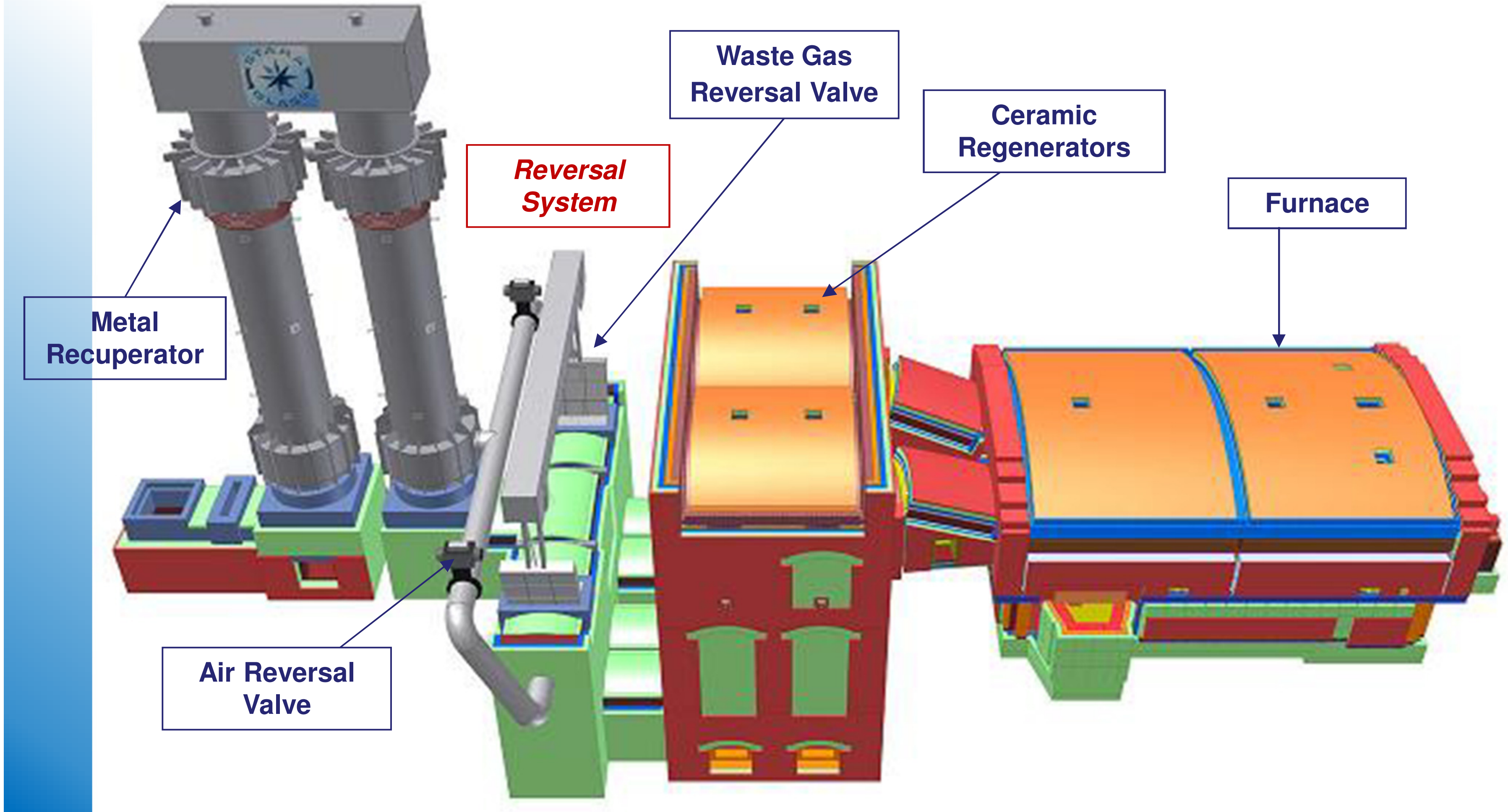


Typical temperatures profiles along a ceramic regenerator

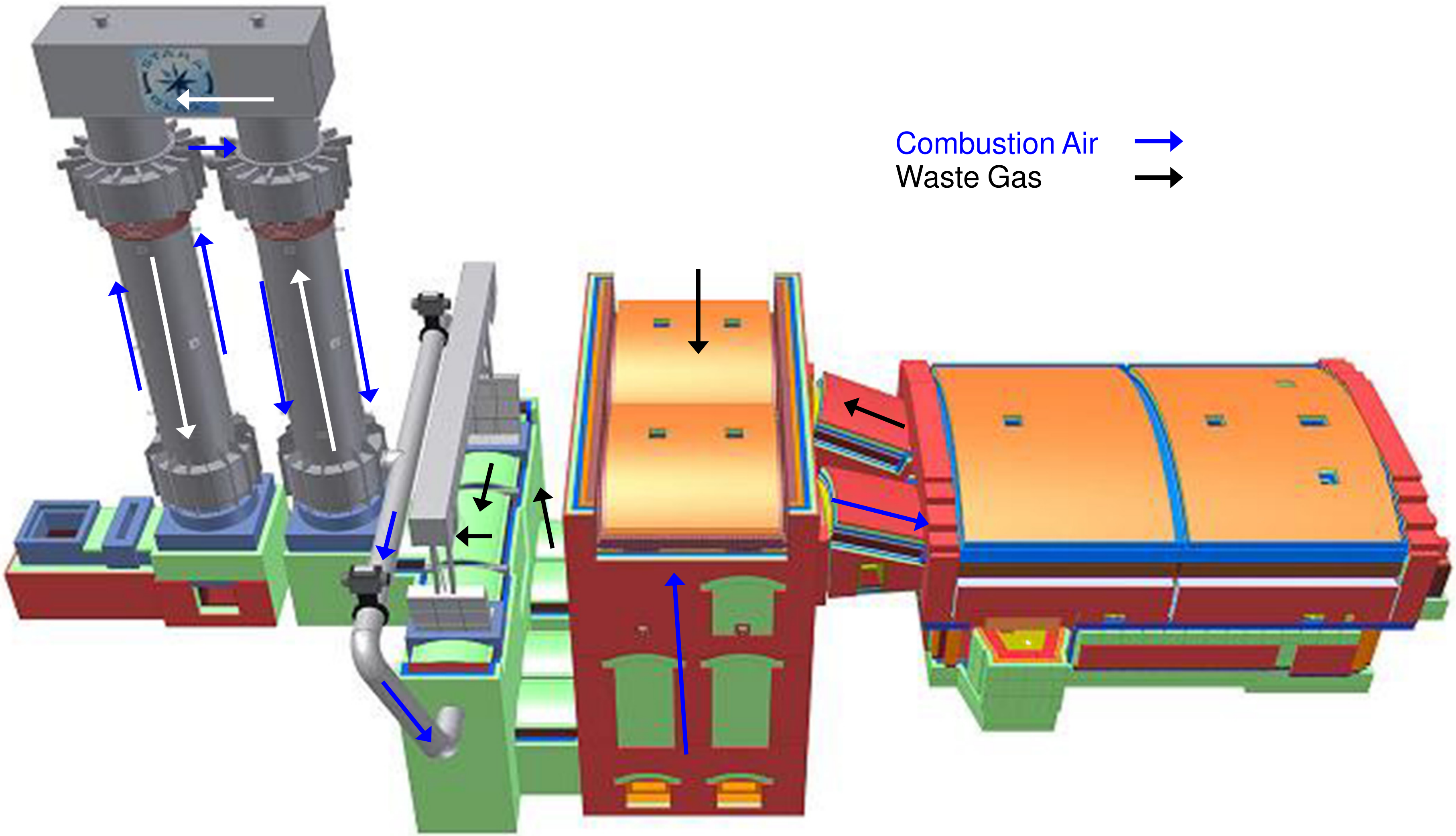
An observation of the air and waste gas temperatures profiles in a regenerator of an **End Port furnace**, shows how **for a large part of the height** (about 60%) the regenerator works at a preheated **air temperature** lower than 800°C.

It is subsequently possible to achieve that **an important part of the heat exchange system can be achieved by** a simpler and more flexible **metal heat exchanger**.

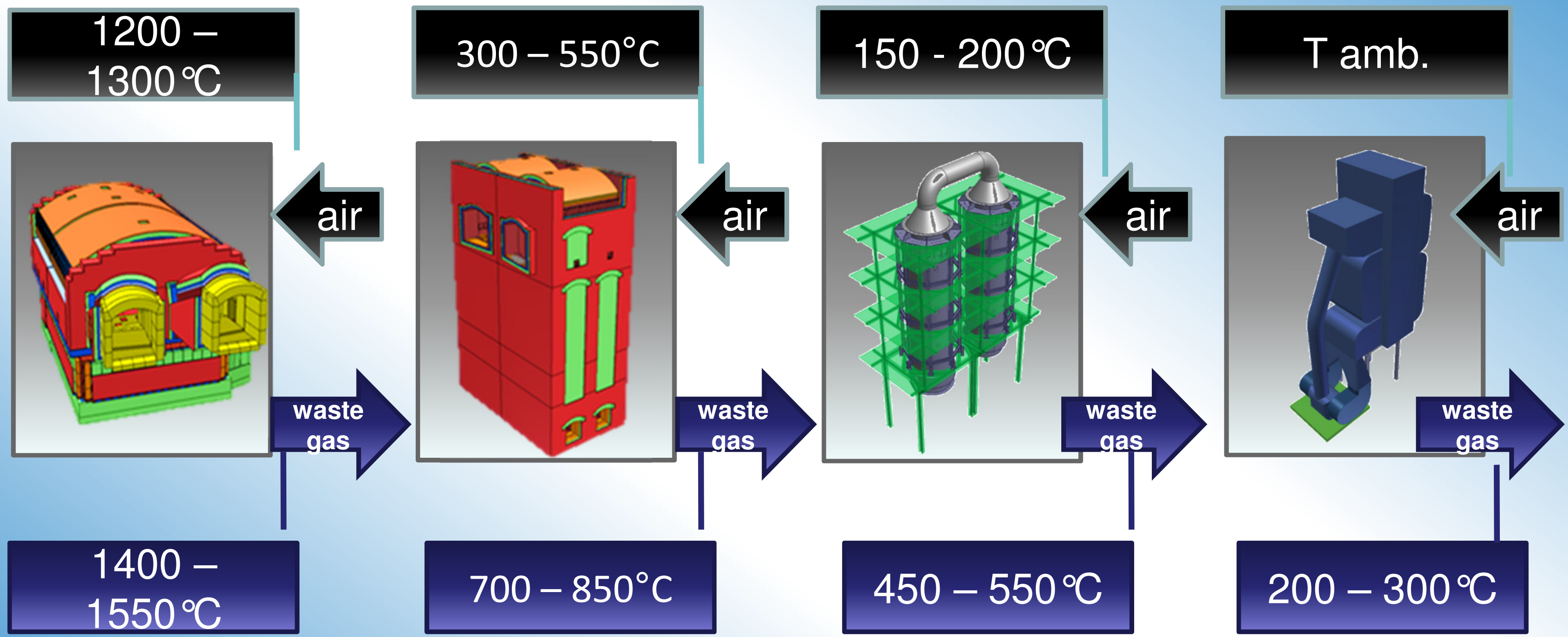
Elements of Centauro



Air and waste gas flows in Centauro

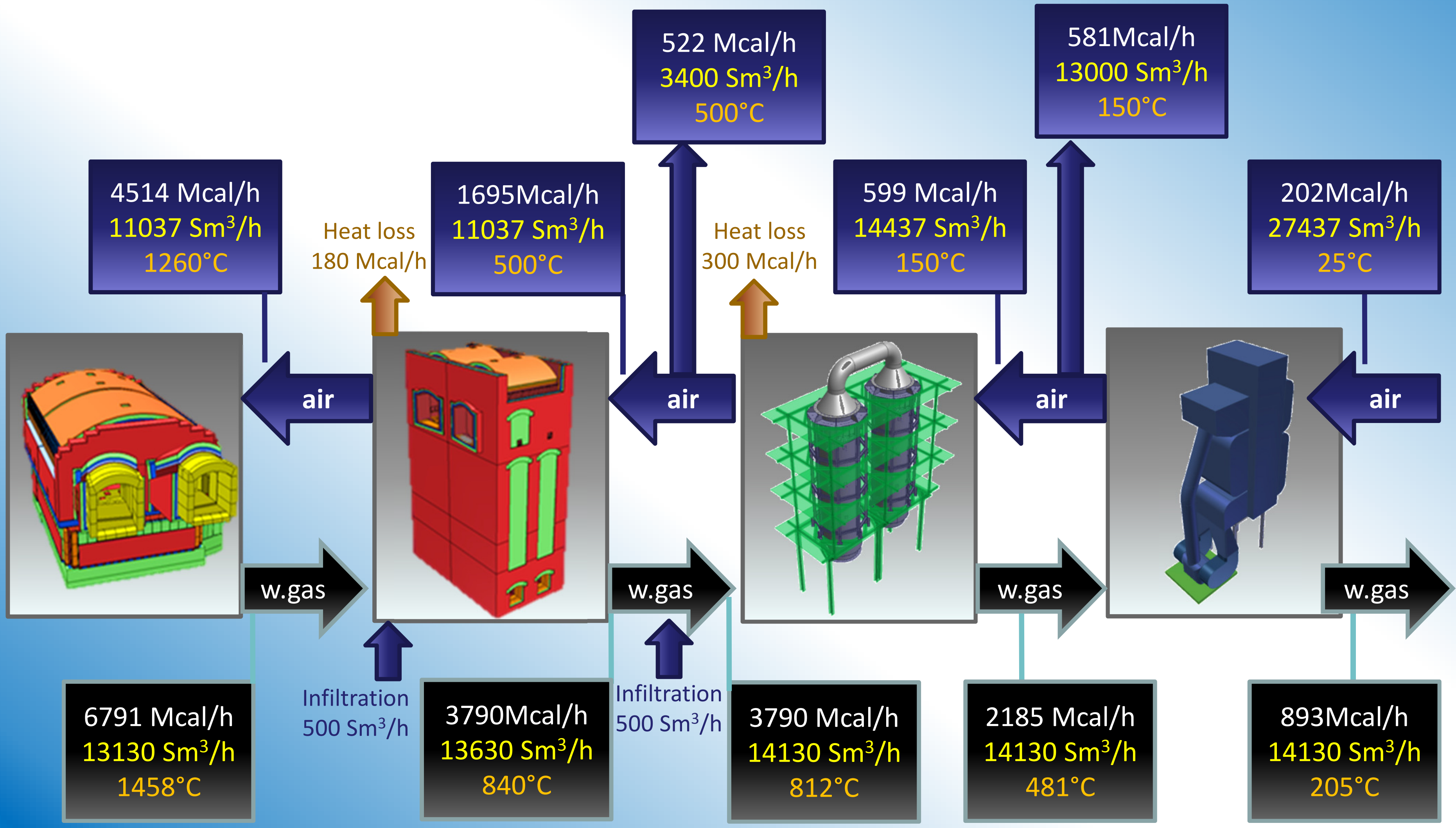


Typical temperature profile along Centauro



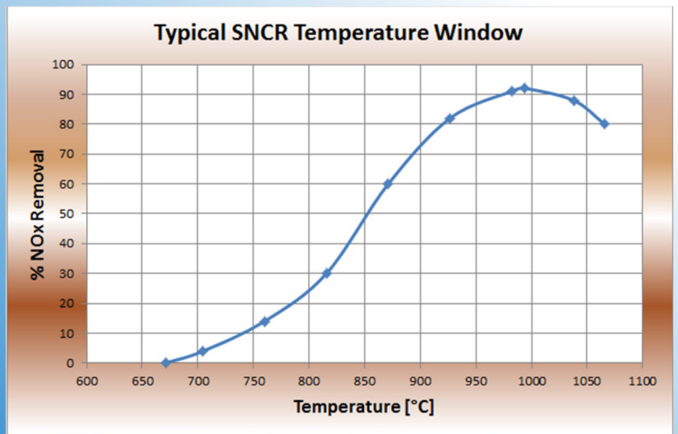
In order to **optimize the thermal exchange in lower temperature zones**, it is usual to add a **convective heat exchanger** to the radiating ones. This kind of component guarantees an high efficiency at low thermal levels and a noticeable design flexibility, and its physiological stops for maintenance and cleaning, thanks to a proper bypass system, penalize the plant efficiency only for a few percent point, commonly for a few days a year.

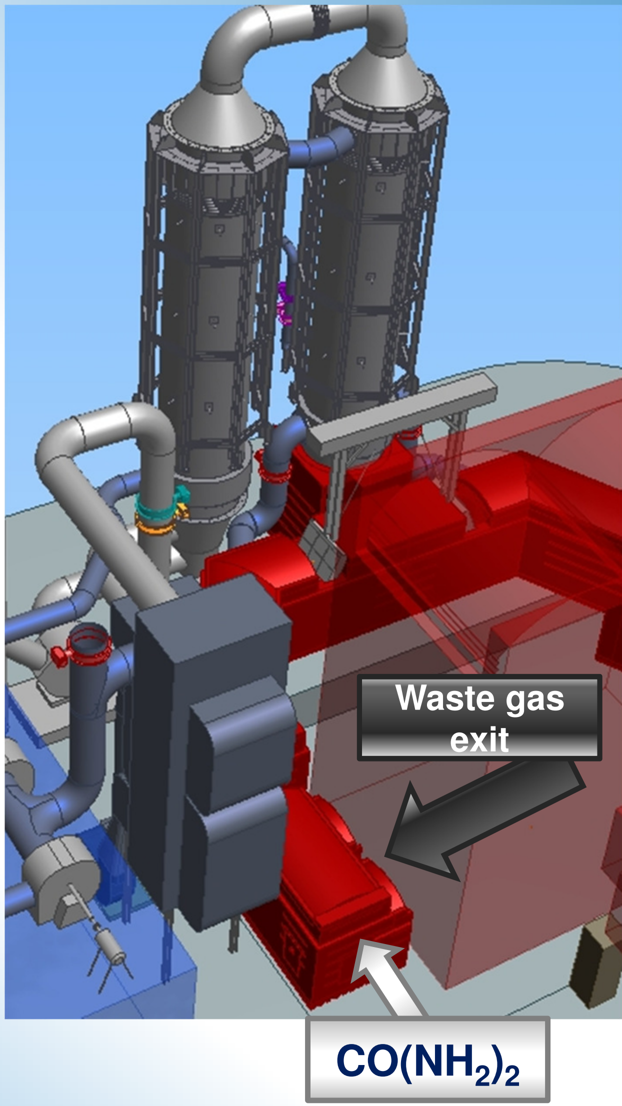
Example of Centauro thermal, energy and mass profile



SNCR system for Centauro

About **NO_x abatement**, Centauro thermal profile can be designed in order to have, in the waste gas duct that connects regenerators and recuperators, a temperature in the window of 800-900°C, that allows the non catalytic abatement of nitrogen oxides, by the injection of ammonia or, more conveniently, urea. In traditional End Port furnaces this window remains inside the regeneration chambers, actually excluding the possibility of using a SNCR system and imposing, for nitrogen oxides containing, the usage of a more expansive and complicated catalytic system.





Centauro system additional hot air

Centauro offers an important chance to improve the global efficiency of the glass production plant.

By oversizing metal heat recovery system in order to allow the flowing of a superior amount of air than what is requested for the combustion, and taking out the air excess before the refractory section of the system, it is possible to **extract an important additional part of the thermal energy stored in waste gas, reducing its temperature to the lowest required level** (usually about 200°C, to avoid acid condensation, instead of 450-500°C typical of a regenerative furnace or 800°C and more for recuperative furnaces). This way **the additional energy will be available as an hot clean air flow**, easily extractable at the end of each stage of the metal part of the recovery system, that can be useful both in process and in services.

In the red circle on the side, the pipe to extract the air excess at the end of the hottest metal heat recovery stage of a Centauro system, photographed during the construction of the plant.

Centauro: a new conception

Centauro is an innovative **hybrid regenerative/recuperative heat recovery system** for glass furnaces, under **Stara Glass' patent.**

Centauro is a **new conception** furnace which **uses consolidated** and **field tested technical solutions:**

- **Metal Recuperators** work in a less severe conditions than in a common *Unit Melter.*

- **Regenerators** in the top part (high temperature zone) work exactly as standard End Port ones, while in the bottom part they work at higher temperature conditions than in a standard End Port furnace, allowing the reduction or elimination of sulphates condensation (depending on regenerator height), with consequent lower losses in performance and elimination of related problems.

- **Reversal valves** for high temperature application guarantee the **highest reliability and duration** in time together with high seal performances (reduced air losses to waste gases).

Centauro key features

Centauro system guarantees **at least** the performance of a well dimensioned End Port furnace with some additional **advantages**:

- Flexibility in lay-out
- Reduced depth of regenerators
- Better working conditions of regenerators (higher thermal homogeneity / reduced condensation)
- Reduced exhausting/cleaning period during reversion
- Clean hot air stream available (additional free thermal power)
- Flexibility in temperature *cut* level between regenerative and recuperative cycles

Centauro is a new conception furnace with high thermal performances united to geometrical advantages, that gives an **important chance** for **rebuilding / converting / empowering** a furnace, minimizing the surrounding impacts and costs.

Unit Melter conversion

The main problems/limitations that arise for a **Unit Melter to End Port conversion** are typically:

- Lack of technical space needed for realization
- Construction time
- Civil works investment
- Furnace investment
- Presence of ground waters

With **Centauro** it is possible to:

- Reduce regenerators height and digging operations
- Modulate regenerators height based on actual needs
- Choose and optimize the position of metal recuperators in the existing layout of the plant

End Port optimization

Enlargement of EP furnace: for increasing productivity, often is not allowed by layout constraints, requiring huge civil works. Often the subsequent decision is to increase the pull through the addition of an electrical booster system (high operational costs).
The flexibility of Centauro often allows to find a **winning solution**.

End Port Furnaces with double pass chambers: Centauro allows the **elimination of second chamber** and of all the well-known related problems.

End Port Furnaces with checkers with undersized height: Centauro allows to improve the heat recovery system **significantly reducing the amount of civil works**.

End Port Furnaces with checkers of undersized section: in case of necessity of increasing the productivity with constraint on modification of the chambers geometry, Centauro allows to modify checkers's geometry **reducing waste gas velocity in the checkers** and **moving a part of the heat recovery to the metal recuperators**.

Real case 1

Double pass End Port conversion

The **Bormioli Luigi furnace** in **Abbiategrasso (Milan – Italy)** represents the first example and real case of the advantages that Centauro can offer.

The furnace, that produces extra-white perfumery ware, has been built by **Stara Glass** making a complete conversion and rebuilding of a formerly double chambered End Port.

To obtain the pull requested by the customer, **the regenerators pit wasn't deep enough (-3000 mm) to allow the achievement of a performing single pass regenerator**, while the rebuilding of a double pass regenerator was expensive and technically not satisfactory for the company.

A deeper excavation being disadvantageous in the location, while the company was already resigned to installation of a multiple chambers furnace, Stara Glass' proposed the **Centauro solution**.

The Centauro system was designed and optimized, using the existing height of regenerators and eliminating the second pass, substituted by a properly dimensioned metallic part. **The important reconstruction savings joined the significant energy savings deriving from this solution, due to the higher energetic efficiency achieved in the heat recovery system**.

Real case 2

Unit Melter conversion

The **O-I furnace in S. Polo (TV - Italy)** represents a second example and real case of the advantages that Centauro can offer.

The furnace, that produces colored glass for container, has been built by Stara Glass on an formerly Unit Melter furnace, which had to be completely rebuilt.

To obtain the pull requested, the previous existing Unit Melter had a big melting tank and, due to lower heat recovery performances, a high energetic consumption.

Due to land situation, a deep excavation for transformation to traditional End Port technology was considered not applicable, so the company was already resigned to keep existing Unit melter with the higher operational costs deriving.

Stara Glass' technicians proposed to solve the problem with a Centauro, with the target to limit at minimum the excavation work. The design choice of the system allowed that **bottom floor of regenerator derived is only is -1,5 m below machine floor**. The glass production started in May 2011 and the **saving aspects deriving from this solution resulted hugely significant**, keeping same productivity of previous furnace.

O-I plant managers, according to a suggestion by Stara Glass engineers, decided to use the hot air excess to warm the factory and, lately, to employ it also for the process.

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