



More than 60 years of high performance

Stara Glass



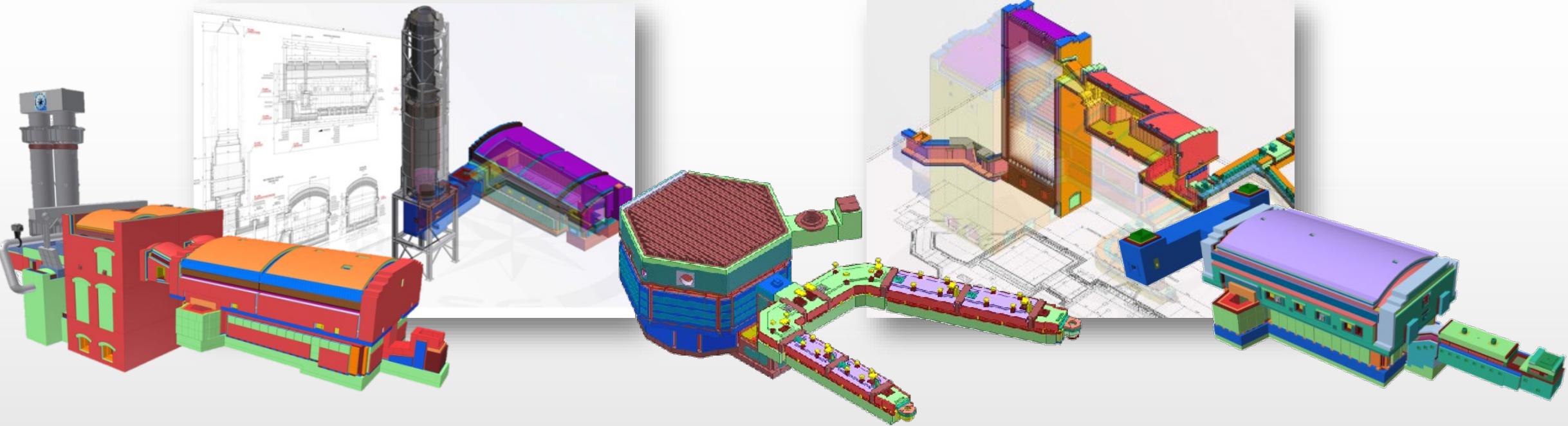
Thermal design and R&D department

A Company of Hydra Group





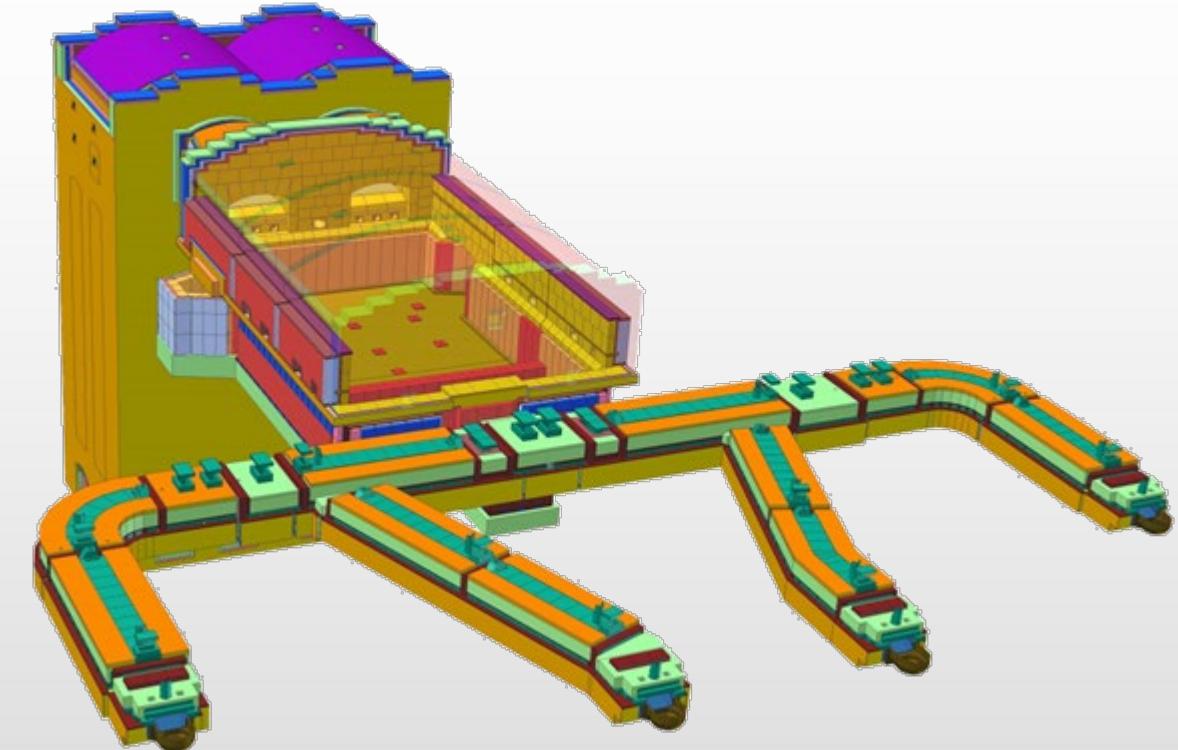
Thermal design and R&D department



Stara Glass excels at the design of glass furnaces (end-port, unit melter, oxy-fuel, electrical, hybrid) thanks to its constant will to improve and its extremely wide technical expertise. Stara Glass realizes **its own design software, basing of hundreds of field data and operating furnaces detected and computed heat balances**. Stara Glass can therefore offer performance guarantees.



- **Stara Glass design tools**
 - Advanced glass furnace design
 - *GFS Glass Furnace Simulator ©*
 - *Regenerators ©*
 - Recuperators (*CDR Sim, PDR Sim, PTR Sim ©*)
 - *Other models*
- **CFD aided design**
- **Heat balance service**
- **Hybrid furnaces**
- **Environment protection technologies**
 - *SNCR system for Centauro*
 - *Strategic waste gas recirculation*
 - *High-efficiency air staging*
- **Financed research projects**
 - *Prime Glass*
 - *Others*
- **Patents**





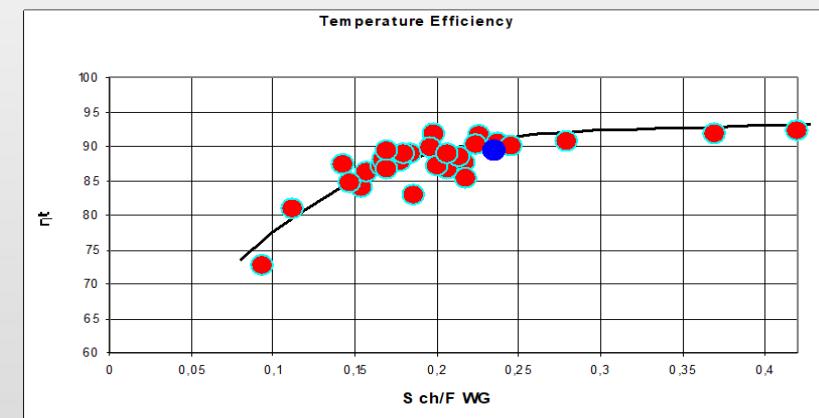
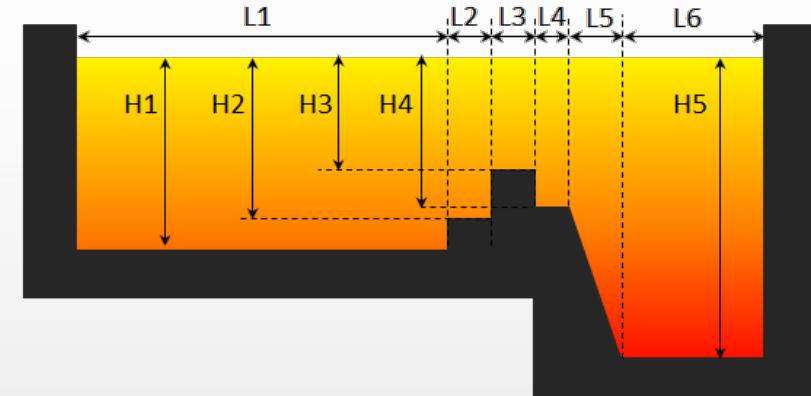
Advanced glass furnace design

Stara Glass constantly strives to provide its customers with more performing solutions, both on a energy and ambient protection point of view, and for creating more evolved, accurate and reliable design tools. Few examples:

Specific Useful Heat: while furnaces' sizes are typically dimensioned basing on the specific pull (ton/m²day), this parameter does not consider the different product type, cullet utilization etc. and can hardly be a measure for glass quality. Instead, together with this basic indication, we prefer to relation the melting surface with the heat that is provided to the glass (MW/m²), thus being able, through the analysis of hundreds of statistical data, to see what the furnace pull can be, whether it produces bottles for water or high quality perfumery

Residence time of the glass in the tank: while the average value is set by pull and furnace size, we use statistical and CFD analysis to evaluate what will be the minimum residence time, which is the main cause of glass defects.

Regenerator design: since the furnace size is not a sufficient parameter to dimension its recovery system, we compute the air and waste gas volume and we classify regenerators basing on the ratio between exchanging surface and waste gas flow (m²/(Sm³/h)).



All of our models are fine tuned with an always increasing collection of field data.





Design tools: Glass Furnace Simulator - GFS ©

GFS allows the designer to precisely define all computing input and to collect all the significant output. The model has been tuned on hundreds of real heat balances and in its thermal-dynamics is based on a physical, non-empirical modelling. GFS computing includes:

- Evaluation of the **specific useful heat**, that we introduced as a primary design criterion
- Accurate simulation of **regenerative, recuperative, oxy** and **Centauro** furnaces
- Generation of **consumption curves**, depending on each significant parameter or working condition (pull, boosting, glass temperature, preheated air temperature, cullet utilization, thermal loss, mix humidity, etc.)
- **Computing of all thermal and mass flows** involved in the process
- Statistical hypothesis of thermal loss depending on furnace size and product for pre-design
- Statistical hypothesis of infiltrations, holes and leakage
- Gas combustion, oil combustion, oxy-fuel combustion
- **Glass chemistry** (reaction heat, loss on ignition)
- Multi-language output available in English, Italian, French, Spanish, Russian, easily implementable with any language
- Constant update

GFS - Glass Furnace Simulator Regenerative furnace

Main data	Company	-
	Furnace	270
	Pull [t/day]	75
	Melting area [m ²]	1,5
	O2 excess at the port [%]	800
	Boosting [kW]	800
	Glass temperature at the throat [°C]	1370
	Room air temperature [°C]	25
	Furnace waste gas outlet temperature [°C]	1540
	O2 flow [Sm ³ /h] (O2 = 33%)	0
	Fuel: CH4 = 1 ; Dense oil = 2 ; CH4-Oxy = 3	1
	Chamber couples number	1
	Cullet %	75
	Mix humidity %	1,5
	Initial fuel flow [Sm ³ /h]	1500
	Preheated air temperature [°C]	1300
Include holes	➡	

Leak and infiltration Flow	Air port leakage [Sm ³ /h]	50
	Waste gas port infiltration [Sm ³ /h]	150
	Furnace infiltration [Sm ³ /h]	300
	Waste gas chamber infiltration [Sm ³ /h]	200
	Empirical hypothesis	
	Air port leakage [Sm ³ /h]	50
	Waste gas port infiltration [Sm ³ /h]	150
	Furnace infiltration [Sm ³ /h]	300
	Waste gas chamber infiltration [Sm ³ /h]	200
Hole 1	Hole 1 Radiation heat	100 10000

Calculate	Holes	Flow	Radiation heat	Total heat [kcal/h]
	Hole 1 T [°C] [Sm ³ /h]	1400 100	0	51047
	Hole 2 1400 0	0	10000	0
	Hole 3 0 0	0	0	0
	Hole 4 0 Total	0 2800	0 100	0 10000
			Total	51047

Save simulation		Load
Results	Specific pull [t/m ² day]	3,60
	Specific consumption [kcal/kg]	814
	Fuel flow [Sm ³ /h]	1033
	[Nm ³ /h]	979
	Specific useful heat [Mcal/m ² h]	77,1
Economic data	Fuel cost [€/Sm ³]	0,35
	Electric energy cost [€/kWh]	0,11
	O2 cost [€/Sm ³]	0,12
Thermal loss	Regenerative furnace	
	Tank [kcal/h]	1053652
	Waste gas port [kcal/h]	47825
	Air port [kcal/h]	37478
	Waste gas chamber [kcal/h]	194741
	Air chamber [kcal/h]	147109
New? 1=yes	Total	1480804
	↑	
	Empirical hypothesis	
	Tank [kcal/h]	1053652
	Waste gas port [kcal/h]	47825
	Air port [kcal/h]	37478
	Waste gas chamber [kcal/h]	194741
	Air chamber [kcal/h]	147109
	Total	1480804
	Heat % on top chamber	60
	Dust hypothesis [mg/Sm ³]	150
	Air inf. from reversal valve [Sm ³ /h]	500
	Calculated: leak/holes/infiltration	
	Tank	61047
	Port	21366
	Regenerator	
	Total	82413
Consumption curve		
Temperature		
Air port leakage [°C]		1300
Waste gas port infiltration [°C]		30
Furnace infiltration [°C]		30
Waste gas chamber infiltration		30
Pressure		
Chamber top waste gas pressure		0,5
Chamber bottom waste gas pre		-7
Chamber top air pressure [mmHg]		2,8
Chamber bottom air pressure [Pa]		-5
Chamber height [m]		8
NCV [kcal/Sm ³]		8200





Design tools: Glass Furnace Simulator - GFS © - Customer output

Company Furnace	:
Main data	
Pull [t/day]	215
Melting area [m ²]	78
Boosting [kW]	1185
Cullet %	70
Specific pull [t/m ² day]	2,76
Preheated air temperature [°C]	1300
Glass temperature at the throat [°C]	
Furnace waste gas outlet temperature [°C]	1390
O ₂ excess at the port [%]	1540
Room air temperature [°C]	1,5
Mix humidity %	20
Fuel: CH ₄ = 1 ; Dense oil = 2 ; CH ₄ -Oxy = 3	2,2
NCV [kcal/Sm ³]	8200

GFS - Glass Furnace Simulator
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Heat balance				
<i>Input heat</i>	kcal/kg	GJ/ton	Gcal/h	%
Fuel	785	3,285	7,028	86,7
Electrical power	114	0,476	1,019	12,6
Air	6	0,026	0,056	0,7
Total input heat	905	3,787	8,103	100,0
<i>Output heat</i>				
Glass	443	1,856	3,972	49,0
Chemical reactions	41	0,173	0,370	4,6
H ₂ O evaporation	14	0,058	0,125	1,5
Waste gas and leakage	218	0,913	1,953	24,1
Holes	9	0,039	0,084	1,0
Thermal loss	179	0,748	1,600	19,7
Total output heat	905	3,787	8,103	100,0
Fuel [Sm³/h]	857,1			
[Nm³/h]	812,4			
Specific consumption [kcal/kg]	898	± 3%		
Specific consumption [GJ/ton]	3,76	± 3%		
Specific useful heat [Mcal/m²h]	52,9			

Average glass residence time [h]	28,6
Minimum residence time (estimation) [h]	6,7

Cost	3177	k€/Y
	40,5	€/ton
Fuel cost [€/Sm ³]	0,25	
Electric energy cost [€/kWh]	0,125	
O ₂ cost [€/Sm ³]	0,11	

Heat balance

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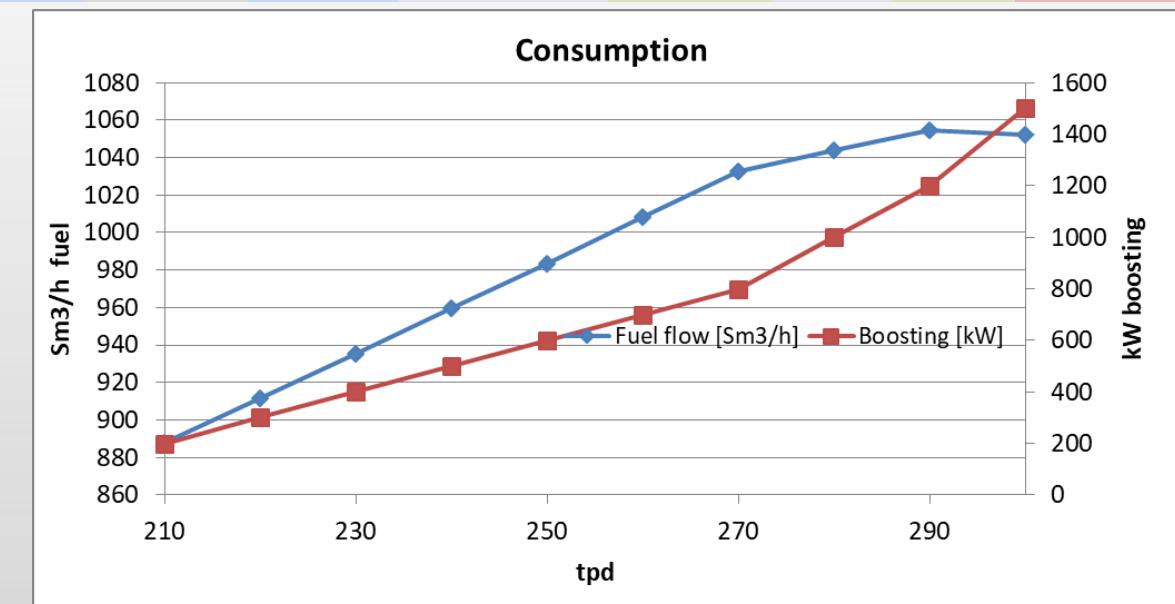
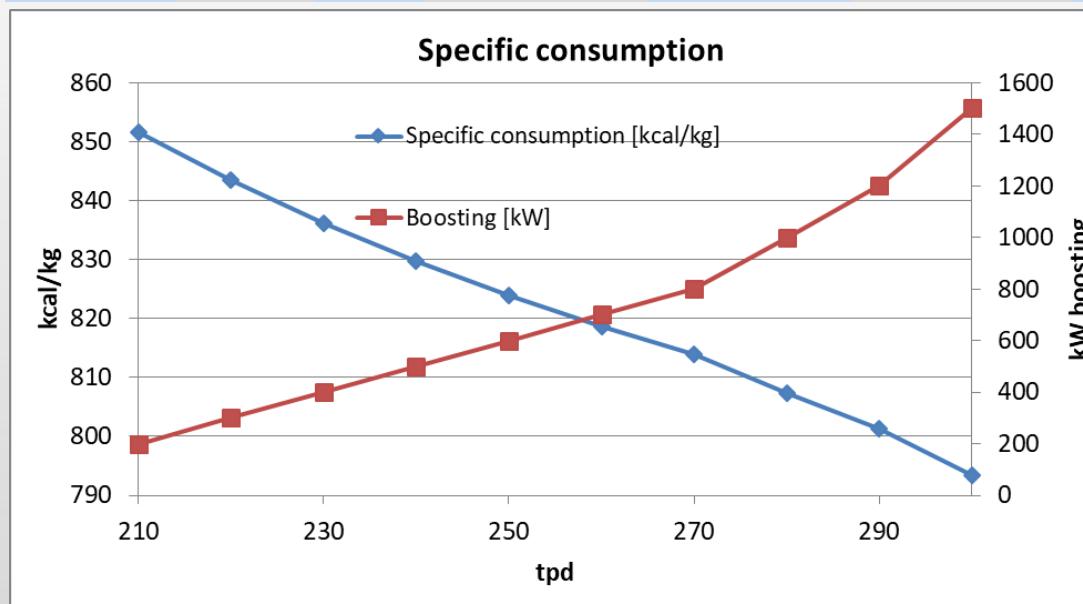




Design tools: Glass Furnace Simulator - GFS © - Customer output

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Pull [t/day]	Boosting [kW]	Cullet %	Glass temperature at the throat [°C]	Furnace waste gas outlet temperature [°C]	Preheated air temperature [°C]	Mix humidity %	O2 excess at the port [%]	Thermal loss [%]	Specific consumption [kcal/kg]	Fuel flow [Sm3/h]	k€/Y	€/ton	Specific useful heat [Mcal/m2h]
210	200	75	1370	1512	1310,2	1,5	1,5	-1,54	847	883	2901	37,8	62,7
220	300	75	1370	1517	1308,5	1,5	1,5	-1,29	839	907	3072	38,3	64,3
230	400	75	1370	1521	1306,8	1,5	1,5	-1,03	833	932	3244	38,6	65,8
240	500	75	1370	1526	1305,1	1,5	1,5	-0,77	827	957	3417	39,0	67,3
250	600	75	1370	1531	1303,4	1,5	1,5	-0,51	822	982	3590	39,3	68,9
260	700	75	1370	1535	1301,7	1,5	1,5	-0,26	818	1007	3765	39,7	70,4
270	800	75	1370	1540	1300	1,5	1,5	0,00	814	1033	3940	40,0	71,9
280	1000	75	1370	1545	1298,3	1,5	1,5	0,26	808	1045	4170	40,8	72,3
290	1200	75	1370	1549	1296,6	1,5	1,5	0,51	803	1057	4400	41,6	72,7
300	1500	75	1370	1554	1294,9	1,5	1,5	0,77	796	1055	4684	42,8	72,0



Multi-condition simulation tool

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Design tools: Regenerators ©

Stara Glass' **Regenerators** software is a transient computing model tested on hundreds of operating regenerators, its main features are:

- Computing of heat recovery with **cruciforms** and **chimney blocks**
- Utilization of the **[exchanging surface / waste gas flow volume]** parameter
- Infiltrations and leakage depending on pressure
- **Fourier series based transient heat storage and release mechanism**
- Under implementation for waste gas recirculation coupled-design computing

Stara Glass - Calcolo camere di rigenerazione

Caminelli lunghezza [Numero]	20	Dim. int. camera [m]	3,69	R [h/m]	0,194	T aria [°C]	1298,8
Caminelli larghezza [Numero]	16		2,96	Sup.Scambio [m ²]	1659,1	Ta tendenza [°C]	1296,8
Distanza impilaggio - lunghezza [mm]	60					Tu fumi [°C]	498,2
Distanza Impilaggio - larghezza [mm]	50					dQ [kcal/h]	6568
Impilaggio: strati alti Corsi [Numero]		H Unitaria [m]		Totale corsi [m]		Caminello [mm]	Sp. [mm]
Tipo 8 Sp. 30 Caminello 150 4		0,4185		1,674		150	30
Impilaggio: strati medi Corsi [Numero]		Tipo 4 Sp. 30 Caminello 150 12		0,4185		150	30
Impilaggio: strati bassi Corsi [Numero]		Tipo 6 Sp. 30 Caminello 330 8		0,175		330	30
H totale impilaggio [m] 8,096							
Portata aria [Sm ³ /h]	7616	Iterazione singola (Ctrl+D)		Calcolo camera (Ctrl+E)		Inizializza (Ctrl+P)	
Portata fumi [Sm ³ /h]	9131						
T fumi pelo impilaggio [°C]	1477						
T ingresso aria [°C]	75						
Inf.Fumi [Sm ³ /h]	250						
n camere	0,7						
Numero di iterazioni	20						
Composizione fumi							
N2 %	65,0						
O2 %	2,0						
H2O %	20,0						
CO2 %	12,0						
Ar %	1,0						
Total %	100						

	mm	Caminelli	Dist. Muri [mm]
Lunghezza	3690	20 x 150 mm	60
Larghezza	2960	16 x 150 mm	50
	N. strati	Tipo	Altezza [mm]
Corsi alti	4	Tipo 8 Sp. 30 Caminello 150	1674
Corsi medi	12	Tipo 4 Sp. 30 Caminello 150	5022
Corsi bassi	8	Tipo 6 Sp. 30 Caminello 330	1400
H tot impilaggio			8096
Ma [Sm ³ /h]	7616		
Mf [Sm ³ /h]	9131		
Tf in [°C]	250		
Tf out [°C]	498,2484		
Ta in [°C]	75		
Ta out [°C]	1299		
R [h/m]	0,19414		





Design tools: recuperator models - PDR Sim ©, CDR Sim ©, PTR Sim ©

Stara Glass' recuperators models compute **parallel-flow and counter-flow double-shell recuperators and tube-nest recuperators**. The software output consists in a precise definition of air and waste gas outlet temperature, depending on:

- **Geometry of the component**
- **Input temperatures and flows**
- **Fouling level**

The software divides the component in 20 zones, in order to precisely evaluate for each zone the chemical/physical characteristic of the fluid (heat transfer, velocity, viscosity, conductivity, convection coefficient, Re, Nu, etc.).

Stara Glass recuperator design features a long-standing experience of the designers in the **delicate evaluation of the fouling levels**, which strongly depends on furnace age and production type.

The models can run **multiple simulations that feature the variation of each parameter**.

Geometrical characteristics of recuperator	
Height of double shell recuperator [m]	7,5
Outside diameter of inside shell [m]	1,50
Thickness of steel sheet of inside shell [m]	0,006
Air gap [m]	0,025
Fouling thickness [m]	0,006

Geometrical characteristics of fins	
No fins	30
Height of fins [m]	7,5
Width of fins [m]	0,02
Thickness of fins [m]	0,006
Distance from one fin to neighboring one [m]	0,157

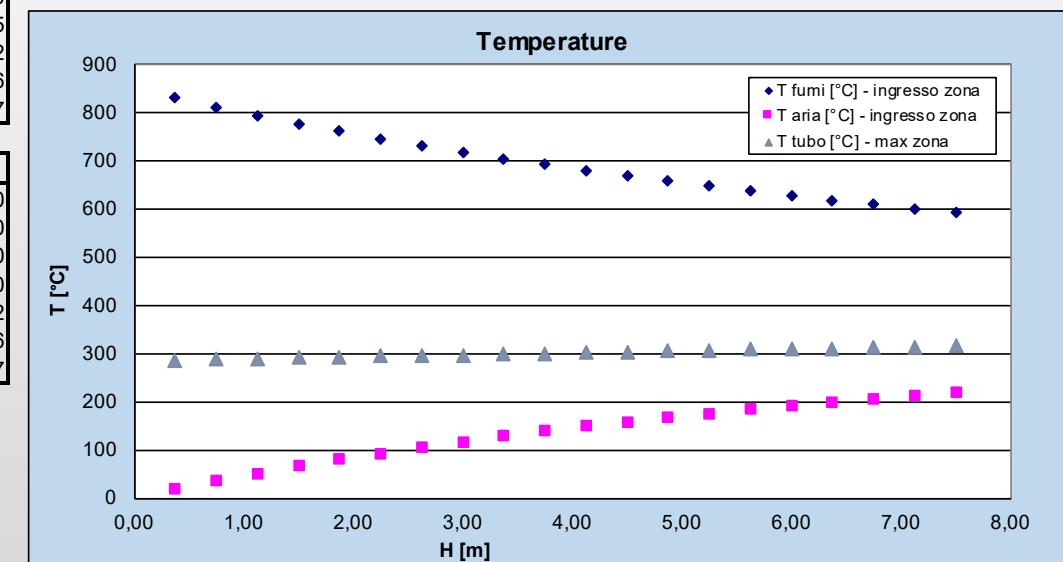
Thermo-physical characteristics of fluids	
Air flow rate inlet [Sm ³ /h]	4500
Waste gas flow rate inlet [Sm ³ /h]	3200
Temperature air inlet [°C]	20
Temperature waste gas inlet [°C]	830
Waste gas heat at the inlet [kcal/h]	890712
Air heat at the inlet [kcal/h]	26486
Total inlet heat [kcal/h]	917197



PDR Simulator

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Thermo-physical characteristics OUTPUT	
Maximum velocity of the air [m/s]	18,92
Minimum air gap [m]	0,0222
Air temperature out from the system [°C]	225
Waste gas temperature out from the system [°C]	585
Air specific heat at the T out [kcal/kg°C]	0,24454
Waste gas specific heat at the T out [kcal/kg°C]	0,27352
Maximum T of metal of the shell [°C]	316
Outlet heat dispersions [kcal/h]	4217
Outlet heat carry out with waste ga	609848
Outlet heat carry out with air [kcal/	303813
Total outlet heat [kcal/h]	917878
dQ waste gas [kcal/h]	280863
dQ air [kcal/h]	277327
dQ total [kcal/h]	680

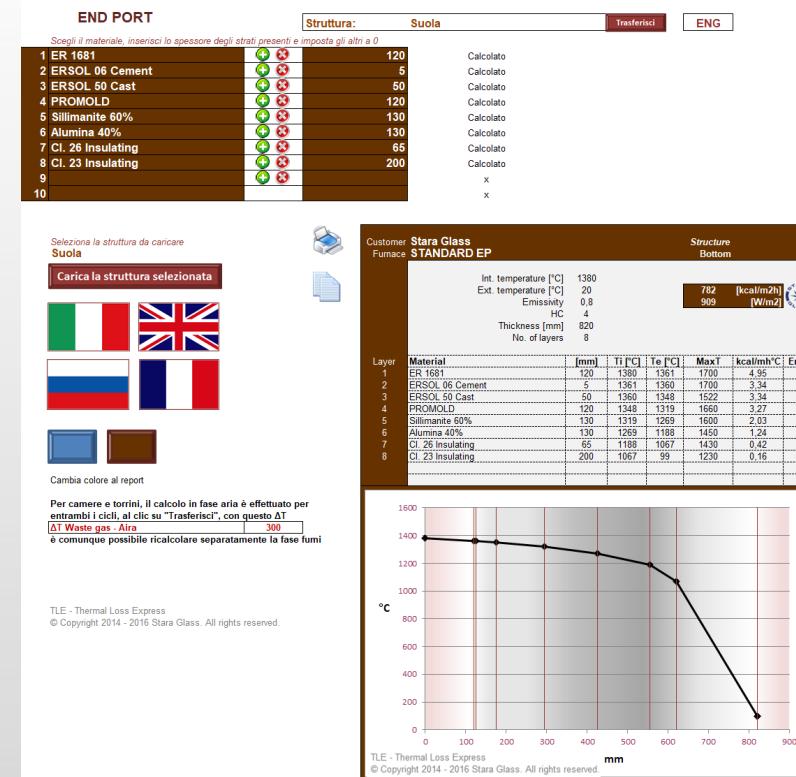




Design tools: Thermal Loss Express (TLE ©)

Superficial thermal loss is computed by a physical model that features the utilization of **more than 600 material**, with their **conductivity curve and limit temperature** based on producer specification. The models allow to compute a complete furnace heat loss (regenerative, recuperative, Centauro, oxy), by the insertion of geometrical parameters. The furnace total heat loss includes the thermal bridge computing, which is evaluated in separate Finite Elements models. **TLE supports a function that allows to foresee the impact on consumption given by the aging of the furnace.**

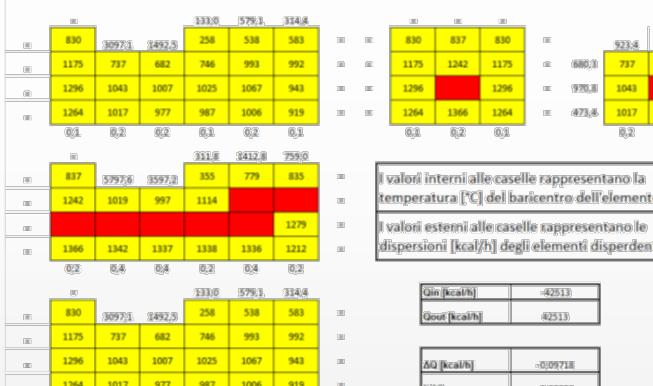
Customer Furnace			Stara Glass STANDARD EP		Zone	Structure	Th. [mm]	Area [m2]	q [kcal/m2h]	q [W/m2]	Q [kcal/h]	Q [W]	Ti [°C]	Te [°C]	Layers	Hc
Zone	Mcal/h	kW														
Tank			Tank	Bottom	820	49,93	782	909	39029	45382	1380	20	8	4		
Tank			Tank	Deep bottom	820	14,92	782	909	11660	13558	1380	20	8	4		
Tank			Tank	Free soldier blocks	250	5,59	16261	18908	90817	105600	1500	20	1	100		
Tank			Tank	Lower soldier blocks	580	19,99	986	1146	19707	22915	1450	20	7	20		
Tank			Tank	Higher soldier blocks	530	5,45	1708	1986	9312	10828	1470	20	6	20		
Tank			Tank	Lower soldier blocks - deep	580	10,73	986	1146	10572	12293	1450	20	7	20		
Tank			Tank	Higher soldier blocks - deep	530	2,93	1708	1986	4996	5809	1470	20	6	20		
Tank			Tank	DH soldier blocks	435	9,75	3799	4418	37039	43068	1450	20	5	20		
Tank			Tank	Side superstructure	565	23,15	888	1033	20560	23906	1550	20	7	20		
Air port			Tank	Throat wall superstructure	565	14,92	888	1033	13251	15408	1550	20	7	20		
A.P. thermal bridges			Tank	Port wall superstructure	565	9,30	888	1033	8263	9608	1550	20	7	20		
A.P. total			Tank	Burner zone	565	1,02	2163	2515	2206	2565	1500	20	4	20		
			Tank	Tank crown	783	68,67	946	1100	64952	75525	1560	20	6	20		
Total tank	1027	1195														
Air port			Air port	Air port - chamber side bottom	334	3,98	1341	1559	5343	6213	1250	20	7	20		
A.P. thermal bridges			Air port	Air port - furnace side bottom	258	2,16	2595	3018	5610	6523	1250	20	6	20		
			Air port	Air port - Sidewalls	500	8,29	963	1120	7984	9283	1250	20	6	20		
			Air port	Air port - crown	577	6,76	879	1022	5945	6913	1250	20	7	20		
W.G.P. total	60	69														
Waste gas port			Waste gas port	WG port - chamber side bottom	495	3,98	2044	2377	8147	9473	1550	20	4	20		
W.G.P. thermal bridges			Waste gas port	WG port - furnace side bottom	250	2,16	4116	4785	8896	10344	1550	20	4	20		
			Waste gas port	WG port - sidewalls	385	8,29	1576	1832	13059	15185	1550	20	3	20		
			Waste gas port	WG port - crown	460	6,76	1366	1589	9238	10742	1550	20	4	20		
A.C. total	114	133														
Air chamber			Air chamber	Air chamber - crown	634	19,64	732	851	14366	16704	1250	20	5	20		
A.C. thermal bridges			Air chamber	Air chamber - port wall	605	8,00	892	1038	7135	8296	1250	20	4	20		
			Air chamber	Air chamber - high walls	605	21,73	892	1038	19394	22551	1250	20	4	20		
			Air chamber	Air chamber - medium walls	605	49,87	650	756	32407	37682	850	20	4	20		
			Air chamber	Air chamber - low walls	605	49,87	197	229	9825	11425	400	20	4	20		
			Air chamber	Air chamber - below	835	2,89	129	150	373	433	400	20	4	20		
W.G.C. total	179	208														
			Waste gas chamber	WG chamber - crown	634	19,64	1136	1321	22310	25942	1550	20	5	20		
			Waste gas chamber	WG chamber - port wall	605	8,00	1373	1596	10974	12760	1550	20	4	20		
			Waste gas chamber	WG chamber - high walls	605	21,73	1373	1596	29830	34686	1550	20	4	20		
			Waste gas chamber	WG chamber - medium walls	605	49,87	1100	1279	54868	63800	1150	20	4	20		
			Waste gas chamber	WG chamber - low walls	605	49,87	447	519	22274	25900	700	20	4	20		
			Waste gas chamber	WG chamber - below	835	2,89	293	341	847	985	700	20	4	20		
			Total	Total	1422	1653										





Design tools: TBS and few examples of dedicated finite elements models

Dispersioni termiche gola



Dispersioni termiche	(kcal/m²h) - (kcal/m³h)
Potere calorifico inferiore combustibile	8500 kcal/m³h
Costo combustibile	0.13 €/m³
SPIESA--RISPARMIO su consumo annuale	-61228 €

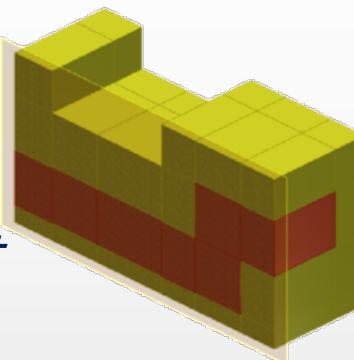
DISTRIBUZIONE TEMPERATURE FINALE [°C]

	167	193	470	560	778	877	907	1060	1231	1394	1449	1462	1492	1524	1535	1550	
157	183	461	746	769	858	885	1025	1210	1389	1447	1400	1519	1532	1550			
147	173	441	726	757	838	889	991	1188	1381	1444	1457	1483	1516	1530	1550		
137	163	421	716	745	818	844	955	1165	1373	1440	1454	1478	1509	1525	1550		
109	141	401	678	731	817	921	1140	1360	1442	1448	1472	1511	1516	1550			
103	131	321	591	692	759	782	957	1063	1320	1406	1421	1464	1500	1516	1550		
99	131	321	591	692	759	782	957	1063	1320	1406	1421	1464	1500	1516	1550		
89	121	301	549	669	692	721	932	1048	1294	1395	1405	1449	1490	1509	1524	1550	
91	121	281	499	601	653	696	895	1020	1248	1353	1396	1431	1480	1503	1517	1550	
79	116	276	448	523	621	656	852	1029	1322	1365	1415	1485	1499	1510	1520	1550	
20	110	249	358	479	589	596	703	903	1097	1250	1367	1372	1431	1493	1504	1550	
44	85	182	227	350	405	422	513	692	873	1046	1065	1182	1401	1489	1493	1550	
20	81	178	220	345	401	415	499	680	861	1042	1056	1168	1400	1486	1493	1512	1550
35	75	172	211	337	395	405	480	656	832	1034	1032	1080	1381	1483	1488	1507	1550
20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	1550	

CALORE TEORICO DISPERSO ASINTOTICAMENTE	1058 [kcal/m²h]
CALORE DISPERSO MASSIMO DAL CALCOLO	1714 [kcal/m²h]
ALTEZZA INTERESSATA DAL CALCOLO	0.665 [m]
CALORE TEORICO DISPERSO DALLA PARTE SOPRA AL CORPIERFO GIA' CONTEGGIATO NELLE DISPERSIONI	702 [kcal/mh]
CALORE TEORICO DISPERSO DALLA PARTE DI PALIZZATA LIBERA- GIA' CONTEGGIATO NELL'EQUAZIONE	12242 [kcal/mh]
CALORE EFFETTIVAMENTE DISPERSO DAL CORPIERFO (MODELLO DI CALCOLO)	-4854 [kcal/mh]

Grandezza interessata da dispersioni	36 [m] · [m²]
Dispersioni termiche	-4854 [kcal/m²h] · [kcal/mh]
Potere calorifico inferiore combustibile	8500 [kcal/m³]
Costo combustibile	0.13 €/m³
SPIESA--RISPARMIO su consumo annuale	-61228 €

3D-Throat



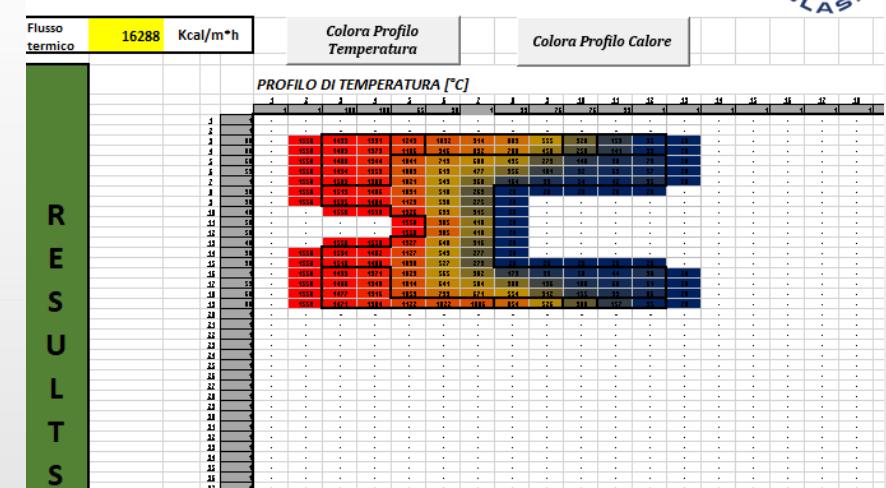
Tuckstones

1550	1497	1411	1308	1147	960.2	734.5	484.2	203.8	20
1550	1493	1393	1245	1034	816.4	573.4	348.7	151.7	20
1550	1491	1368	1117	819.4	608.5	366.4	186.7	115.2	20
1550	1496	1373	1094	739.6	448.2	229.9	114.8	74.22	20
1550	1512	1406	1137	727	20	20	20	20	20
1550	1533	1480	1301	828.8					
1550	1550	1550	1550	1078					
				1550	1123				
				1550	1123				
				1550	1082				
				1533	1481	1314	853.9		
				1550	1405	1169	800.3	20	
				1491	1352	1149	1008	699.4	208.4
								122.3	55.53

Burner

Qin	-35213,0 [kcal/mh]
Qout	35213,1 [kcal/mh]
ΔQ	0,100 [kcal/mh]
%ΔQ	0,000283306

THERMAL BRIDGE Simulator Ver1.4



TBS is a finite elements computing ambient that Stara Glass developed to compute any geometry thermal bridge

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Design tools: other models

Stara Glass' scientific approach to glass furnace design tends to **turn every new computing into a new model**, in order to ensure the repetitiveness and the statistical analysis of the data we manage. Here some example of our software.

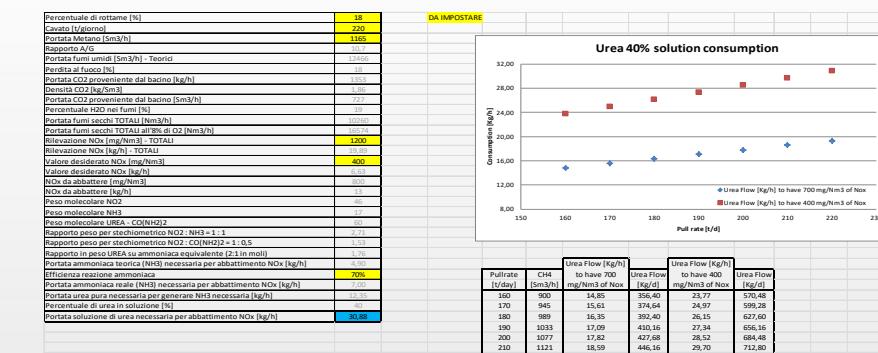
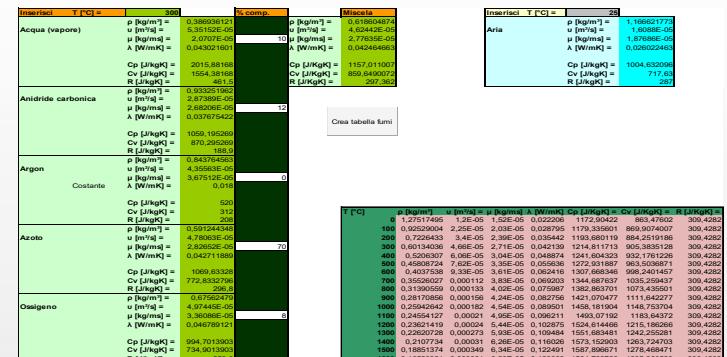
Perdite di carico del recuperatore lato aria		
Recuperatore: -		
<input checked="" type="checkbox"/> Ap distribuite	[Pa] 487,6	[mm H2O] 487,6
<input checked="" type="checkbox"/> Ap concentrate	3032,1	3081,1
Ap totali	35255,6	3686,1
Calcola		
Primo stadio	Secondo stadio	Sigaro CC Sigo EC
Numeri stadi [2]		

Perte distributore aria NB: inserire valori solo nelle celle con caratteri rossi									
Stadio 1					Stadio2				
Da	Aspirazione	Collettore1 SUP	Collettore1 INF	Collettore2 SUP	Dorsale distributore	Bifermentazione	Calefe	Calefe	Bruciatori
a	Costante	Lineare	Costante	Costante	Stadio assente	Costante			
Distribuzione temperatura									
Costante	600	600	170	170	630	630	630	630	630
Temperatura ingresso [°C]	600	170	170	170	630	630	630	630	630
Portata Q [Sm³/h]	10000	10000	10000	10000	10000	10000	10000	10000	10000
Portata Q [m³/h]	8,42	8,42	4,27	4,27	8,71	8,71	4,35	4,35	8,71
Sciacchezza [mm]	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Diametro D [mm]	2000	40	300	400	300	300	150	150	150
D int. intercapedine [mm]	-	-	-	-	-	-	-	-	-
Sezione [m²]	1202	-	1272	-	-	-	-	-	-
Massa volumica p [kg/m³]	1,077	0,077	0,117	0,155	0,071	0,071	0,071	0,071	0,071
Velocità [m/s]	2,48	5,6	6,5	7,6	8,3	8,3	6,16	49,3	49,3
Visc. cinematica v [m²/s]	9,90E-05	3,40E-05	3,14E-04	1,02E-04	1,05E-04	1,05E-04	1,05E-04	1,05E-04	1,05E-04
Lung. della condotta [m]	8	2,7	4	2,7	8	7	7	12	12
Sciacchezza relativa c'D	0,0005	0,00250	0,00033	0,00167	0,00025	0,00033	0,00033	0,0006667	0,0006667
Reynolds	53666	65969175	577628	46559123	262419	174946	1099	69975	69975
λ coeff. resistenza	0,0205	0,0249	0,0163	0,0224	0,0167	0,0168	0,0168	0,0217	0,0217
D [Darcy] [m]	0,0	405	300	81,7	81,2	81,2	215,0	215,0	215,0
Ap [mmH2O]	0,0	1847,4	311,4	1176,4	311,4	308,2	816,0	816,0	816,0
Moto del fluido	Turbolento	Turbolento	Turbolento	Turbolento	Turbolento	Turbolento	Turbolento	Turbolento	Turbolento

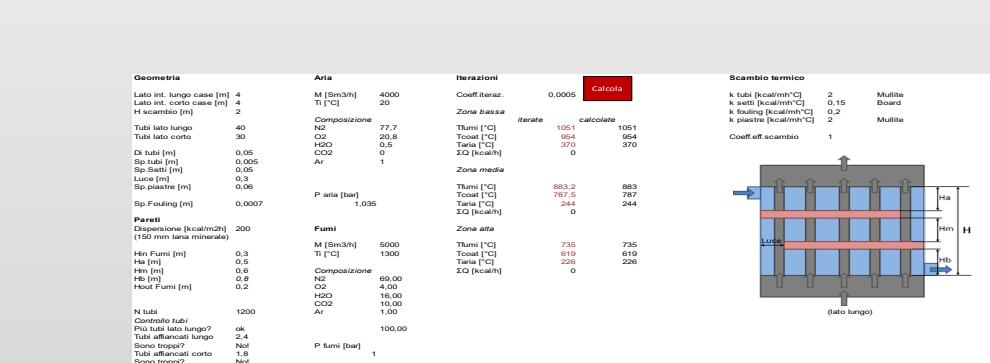
Perte concentratore aria NB: inserire valori solo nelle celle bianche									
Nr. Gomiti [R°]	0	0	2	2	0	2	0	2	0
Nr. Curve	0	0	0	0	0	0	0	0	0
Nr. Sciacch.	0	1	0	1	0	1	0	1	0
Nr. Imbocci	0	1	0	1	0	1	0	1	0
Nr. Allungamenti	0	0	0	0	0	0	0	0	0
Nr. Guinzetti A.T.	0	0	0	0	0	0	0	0	0
Nr. Resistenze	0	0	0	0	0	0	0	0	0
Nr. In/Out Collettore SIGARO	0	2	0	2	0	0	0	0	0
Nr. In/Out Collettore FASCIOS	0	0	0	0	0	0	0	0	0
Massa volumica p [kg/m³]	0,40	0,75	0,78	0,45	0,36	0,36	0,36	0,36	0,36
Velocità [m/s]	2,68	55,67	60,48	76,53	69,34	61,64	49,31		
Σ Totali	1,5	5,5	1	5,6	2,5	12,1	2,5		
Ap [Pa]	2,2	6407,4	1435,0	6603,8	233,0	8921,8	1179,7		
Ap [mmH2O]	0,22	653,95	146,37	673,95	237,97	919,03	120,33		
Ap [Pa] Zona	2,3	8354,4	1746,6	7779,2	2644,1	9231,1	1998,0		
Ap [mmH2O] Zona	0,23	852,15	178,15	793,45	269,75	941,57	203,0		

Unit melter head loss

Chemical-physical parameters of a gas depending on its temperature



SNCR system for Centauro



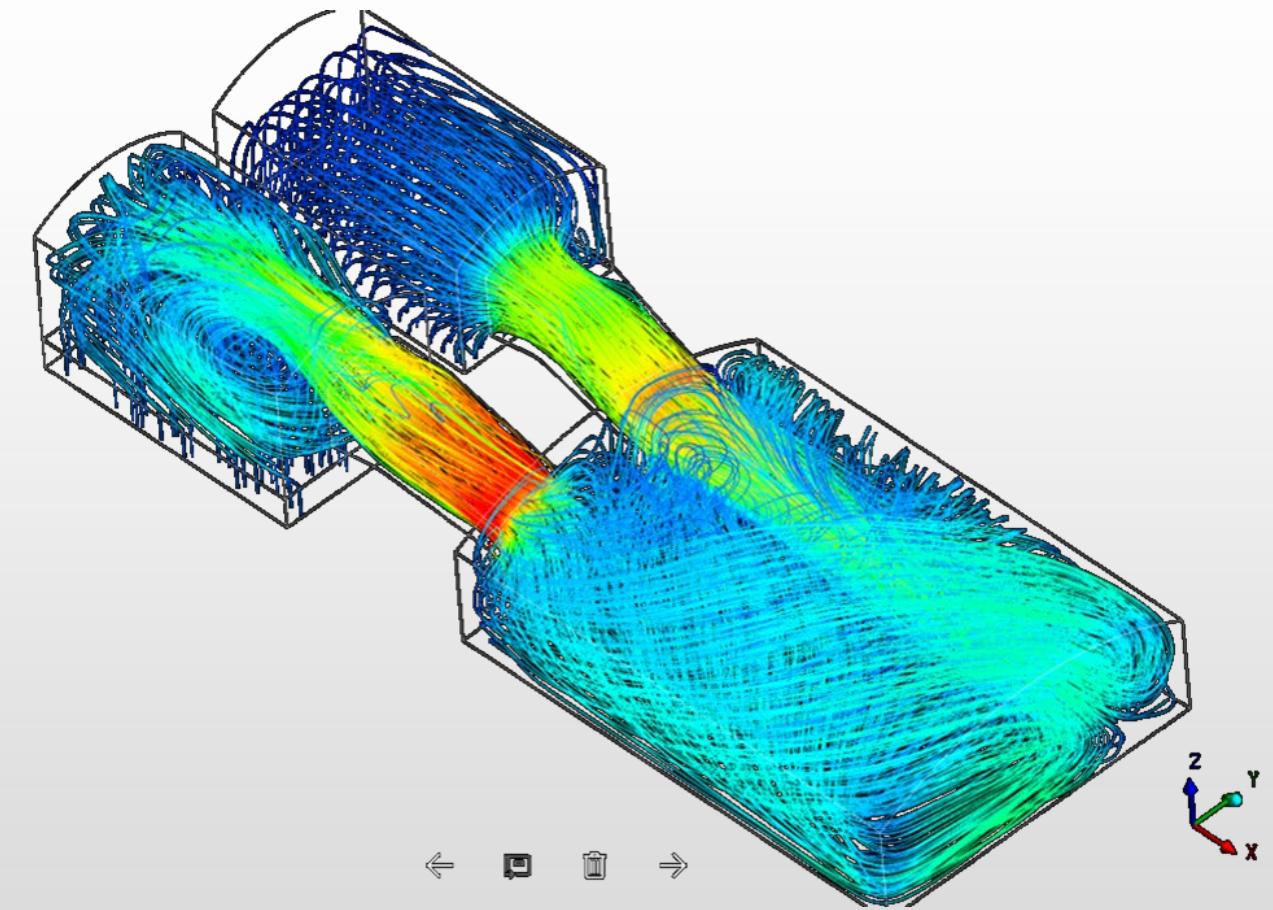
Cross-flow heat exchanger



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Design tools: CFD analysis

In the last years, Stara Glass developed a tight cooperation with the **University of Genova** and the team of Professor Carlo Cravero, that gave us the chance to integrate our design with a CFD analysis our technicians and a large collection of field data allowed to fine-tune.

The tight cooperation has recently evolved in the creation of two innovative start-up's, **SireLab** and **SGRPRO** that are meant to power our CFD computing team and support our field technicians.

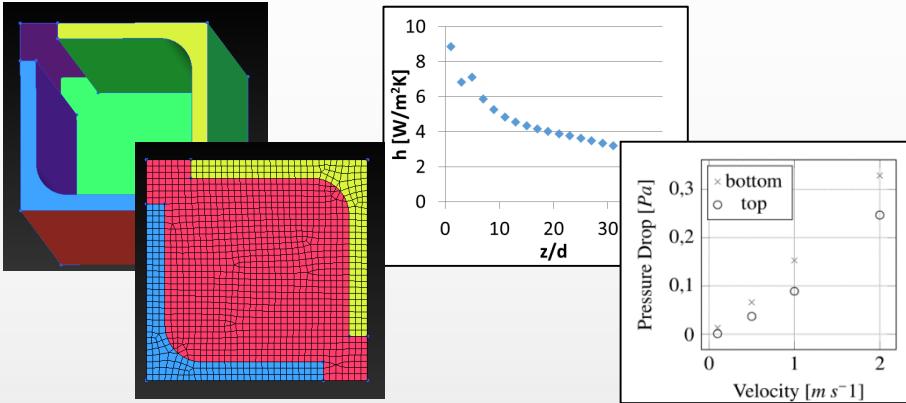
Our current CFD skills include:

- Regenerators and ports analysis
- Flame and combustion analysis
- Hybrid Air-Staging design
- Strategic waste gas recirculation design
- Urea mixing in SNCR systems for Centauro



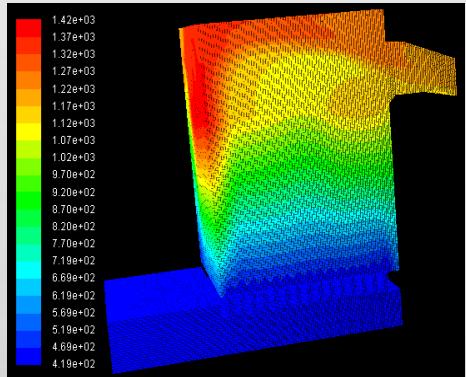
Design tools: Regenerator and port CFD analysis

Checkers zone heat transfer and pressure drop characterization

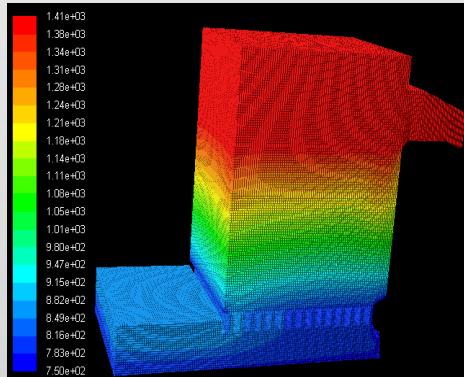


Whole regenerator chamber model

Air phase



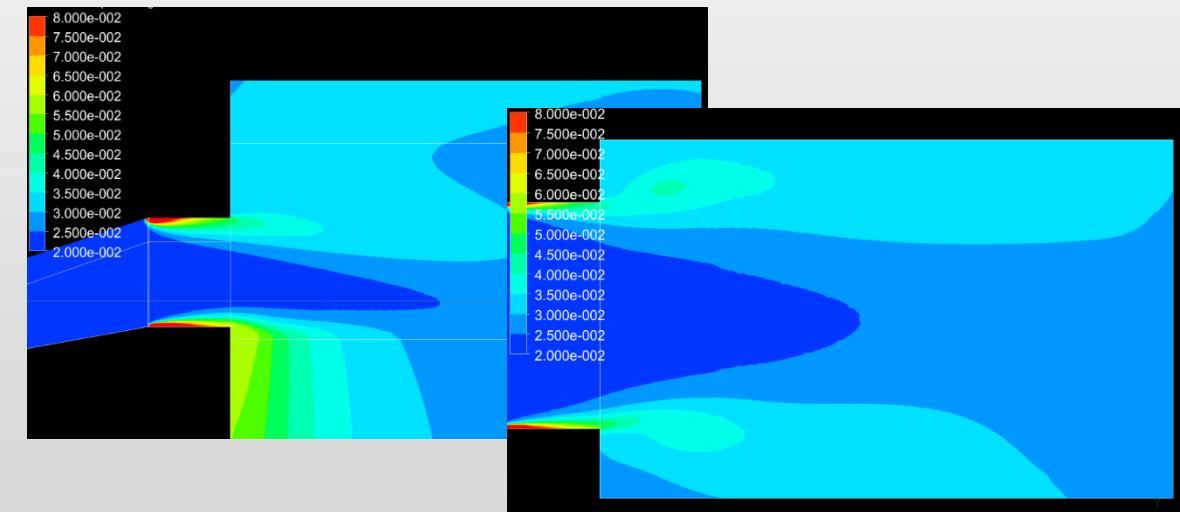
Waste gas phase



The CFD team has developed different tools for the chambers design. In particular, a methodology for the heat transfer and pressure drop investigation in the regenerator checkers zone is developed; its results can be used to set up a simplified 3D model of the whole regenerator chamber.

This methodology provides the basis for the analysis of minor phenomena, such as air infiltration in the waste gas port, or the adoption of particular subsystems connected to the regenerator chambers.

Air infiltration in the waste gas port



Design tools: Combustion CFD analysis

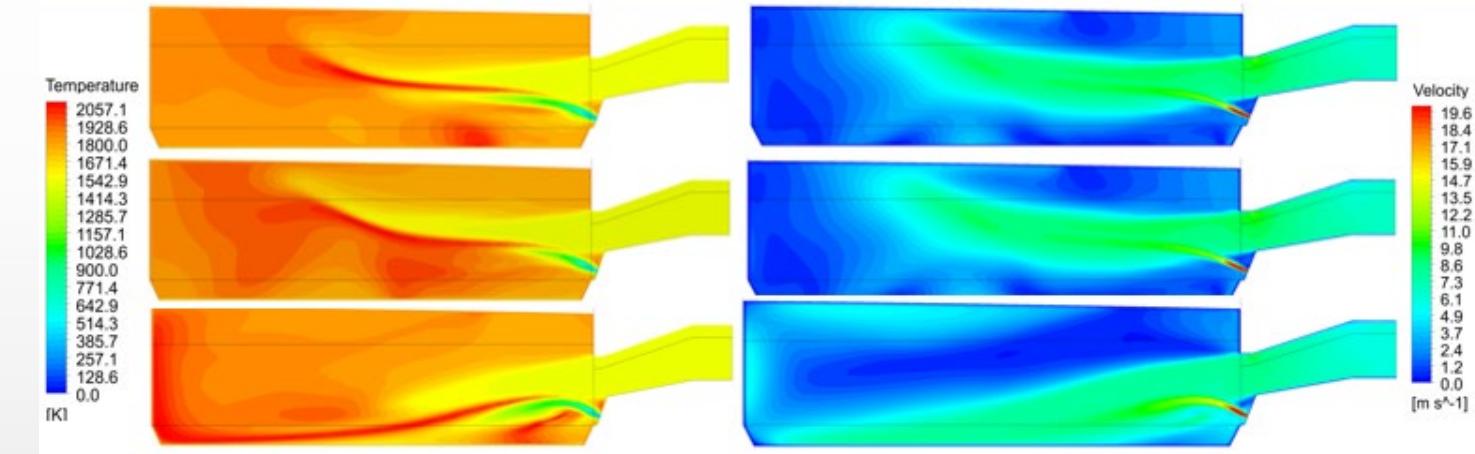
The CFD team has developed specific methodologies for the study of combustion process.

The combustion chamber is 3D modelled, the solver is set up with fine turbulence and chemicals formation models.

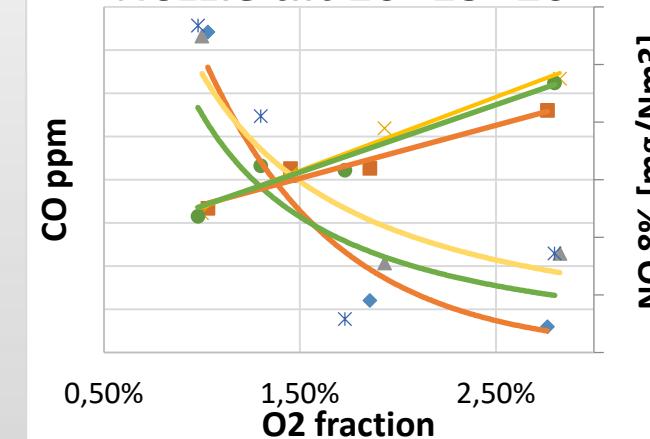
The CFD analysis help the designer to find the best choices by testing and comparing different solution of:

- Combustion chamber geometries;
- Burner geometries;
- Air/ Fuel ratios;
- Furnace pressure;
- Fuels or mix of fuels;

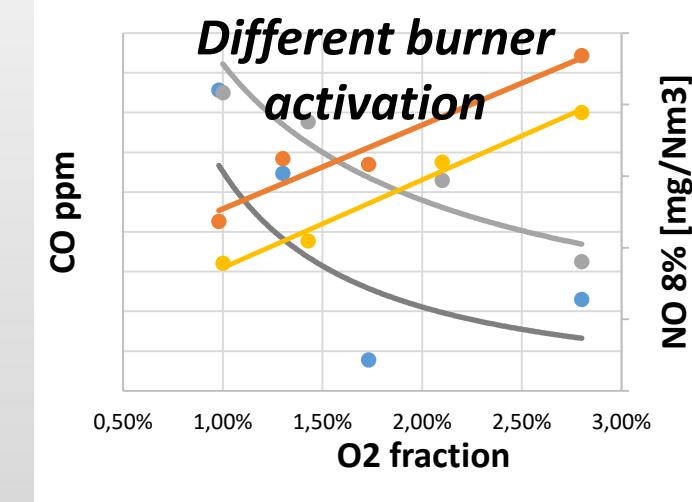
Air/Fuel ratio variation



Nozzle tilt 10° 15° 20°



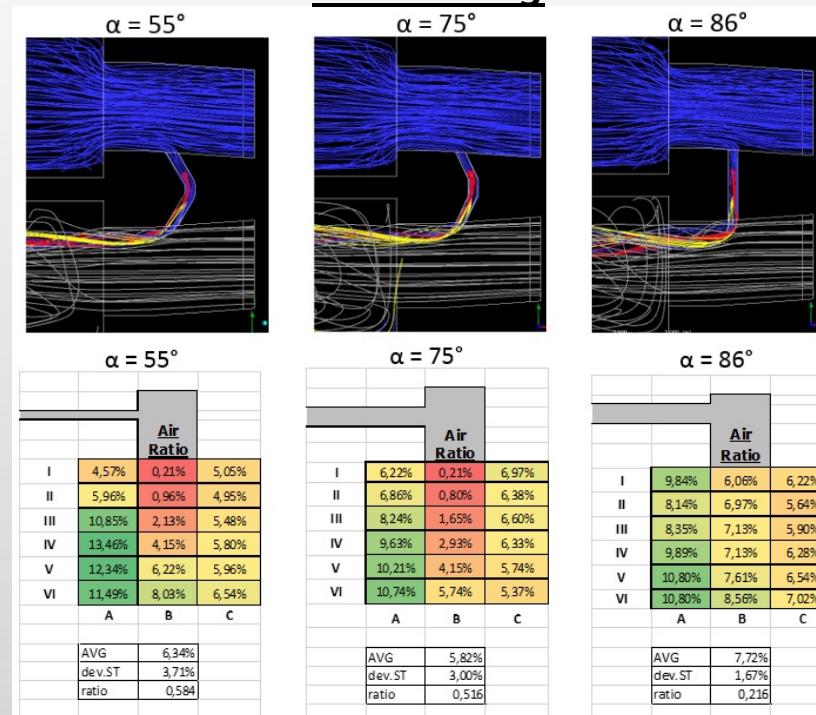
Different burner activation



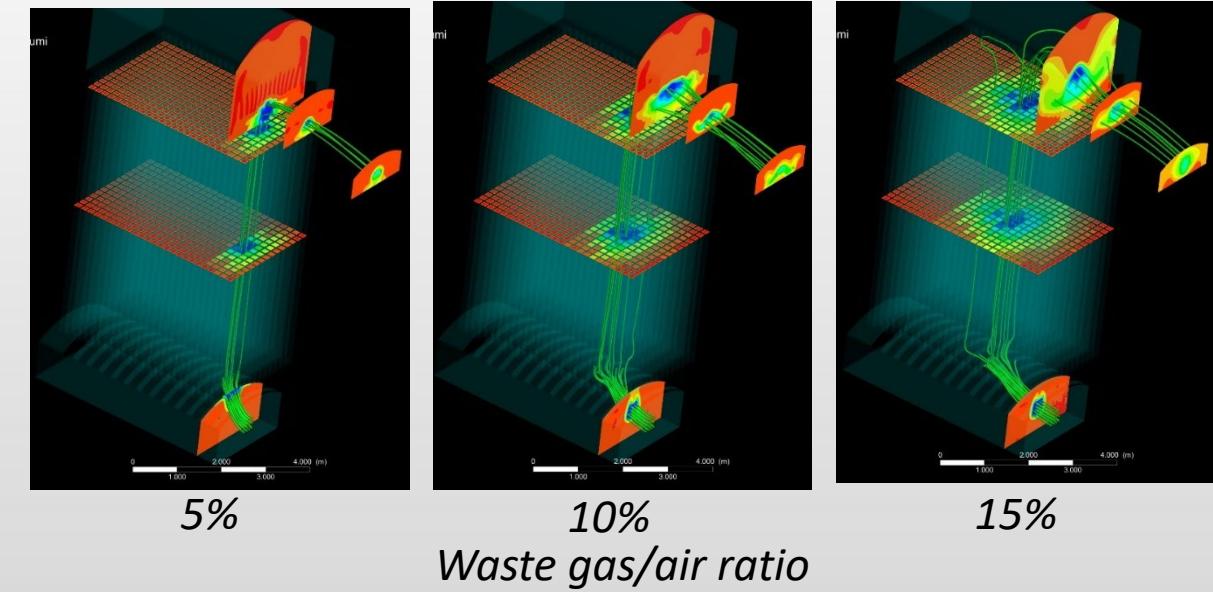
Hybrid air staging & Waste gas recirculation system CFD analysis

The CFD team has developed specific methodologies for the design of environment protection systems such the Hybrid air staging and the Waste gas recirculation system.
 The CFD is a useful technique to tailor the sub-systems geometry and operative settings at each different plant layout.

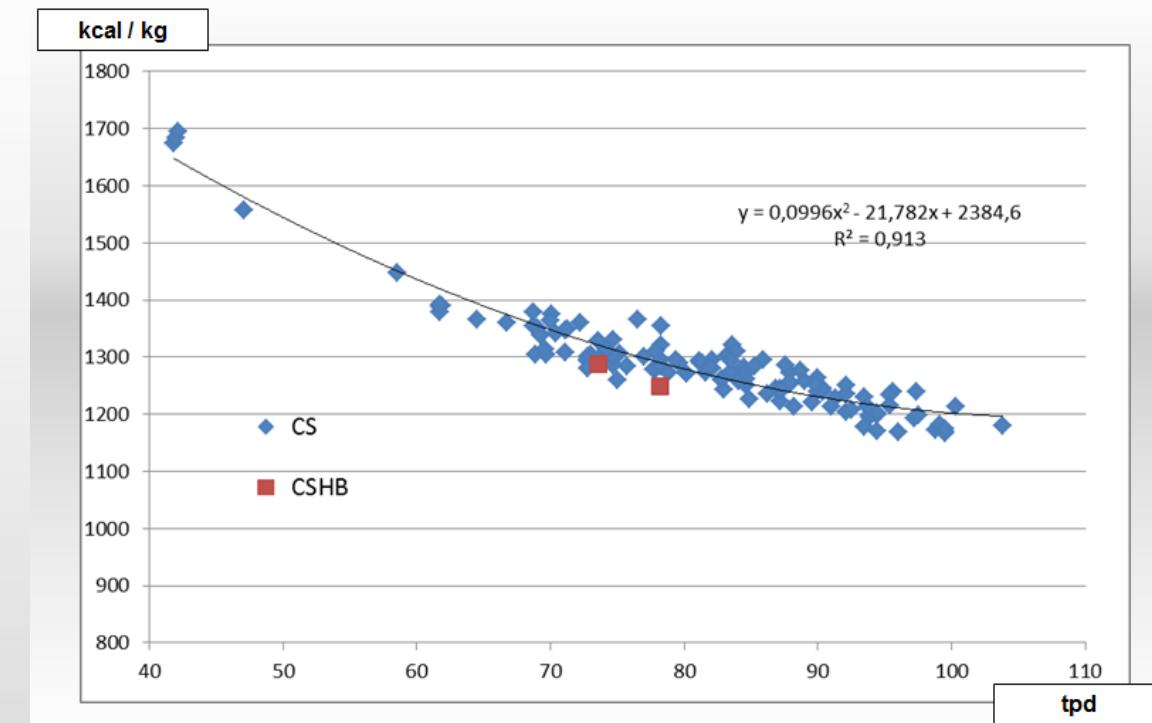
Hybrid air staging system: Air tracking



Waste gas recirculation system: Waste gas tracking



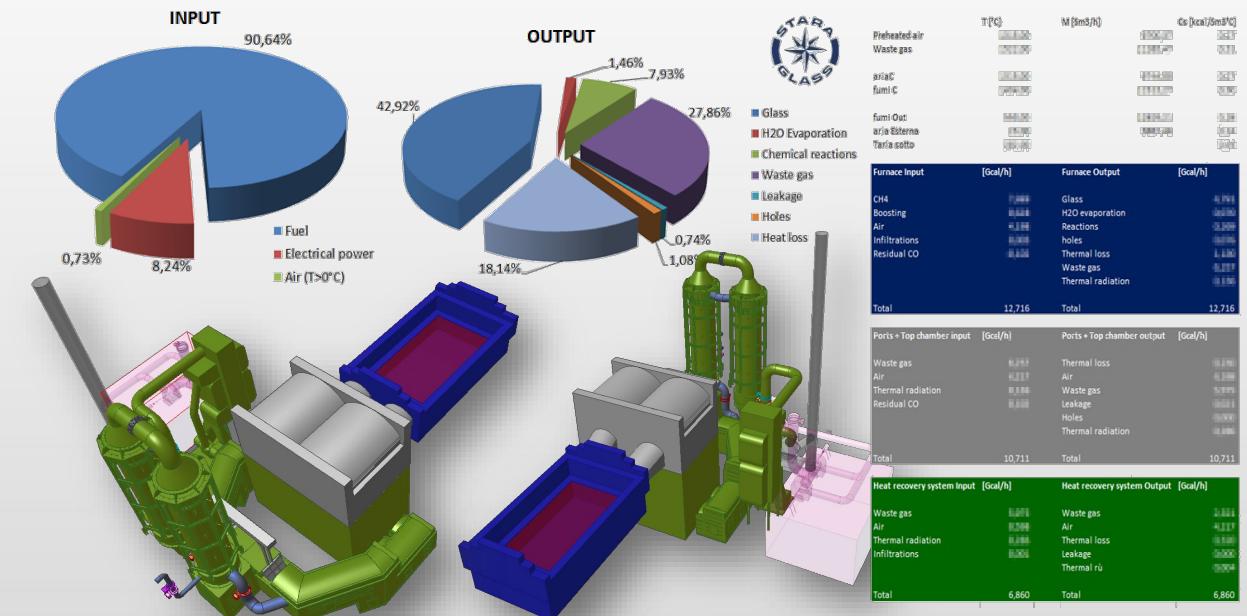
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Heat balance

Heat balance is a 3-5 days campaign of measurements, performed by 3-6 specialists, from which a «picture» of the furnace condition comes out. Often, Stara Glass' technicians, during heat balance period, are already able to provide the Customer with useful suggestions about furnace operation. Once all data are collected, the Customer receives a report that accurately describes the condition of the plant and suggests the strategies to optimize operation. This operation allows to:

- Check the general plant conditions
- **Maximize performance, in terms of consumption and quality**
- **Understand the strong and weak points of the furnace**, in order to solve present problems and optimize next campaign design
- **Verify** the precision of **measure instruments** installed on the plant.



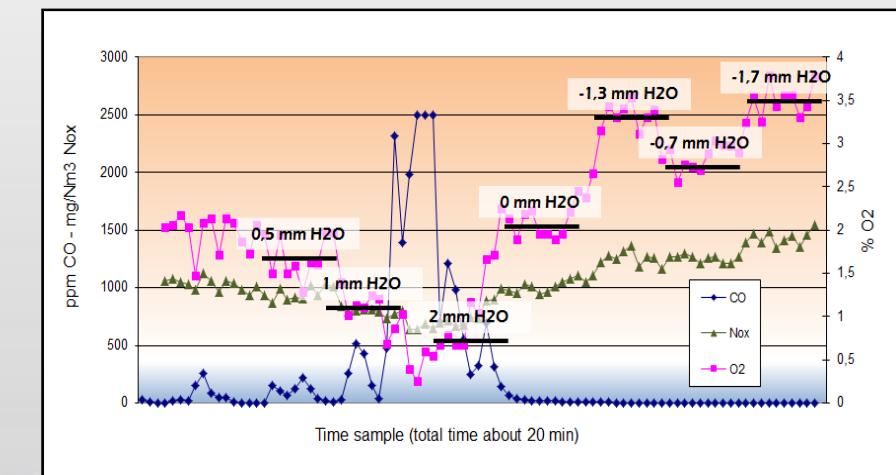
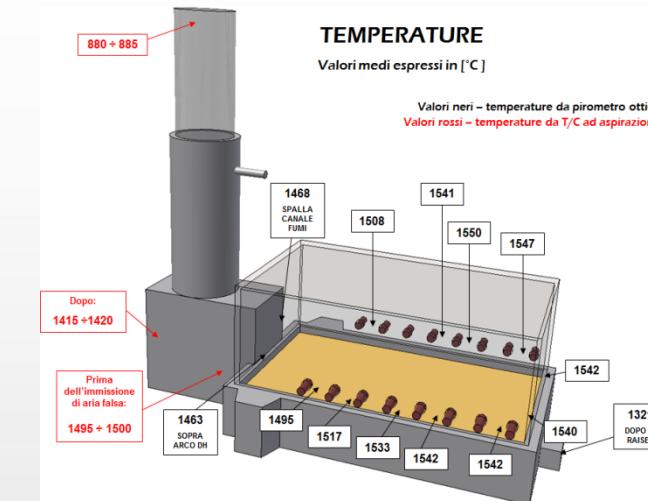


Heat balance

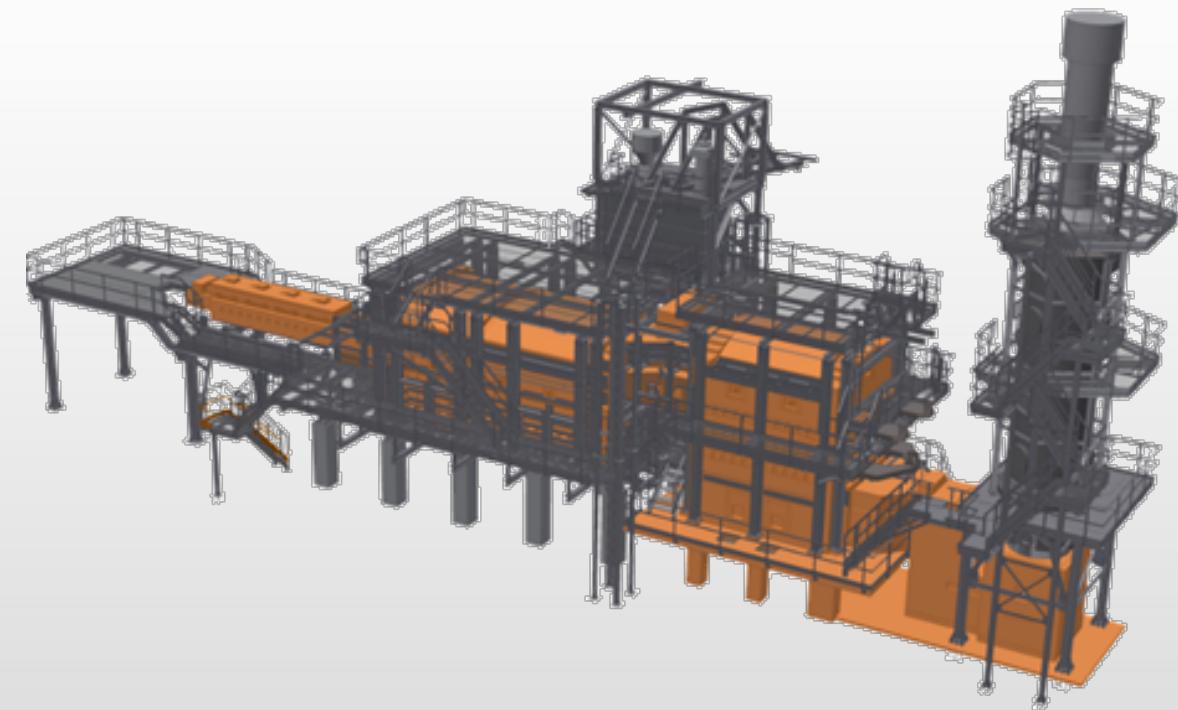
Stara Glass HB team owns the **expertise and the equipment** that are necessary for this high level task. During the operation the following measures are detected:

- **Pressure**, to evaluate the stability of the furnace and possible anomalies of the heat recovery system
- **Temperature**, to verify the heat recovery system and the furnace performance
- **Chemical analysis (O₂, CO, NOx)**, to optimize the combustion from energy and ambient point of view and detect infiltrations
- **Etc.**

The HB activity is important for the optimization of every furnace and it is recommended to be performed at least twice a campaign. Furthermore, the obtained **field data**, that are treated as confidential and never divulged, **allow Stara Glass to tune and update all computing models**, in order to provide the customers with more and more advanced and reliable designs.



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Hybrid glass furnaces: Centauro

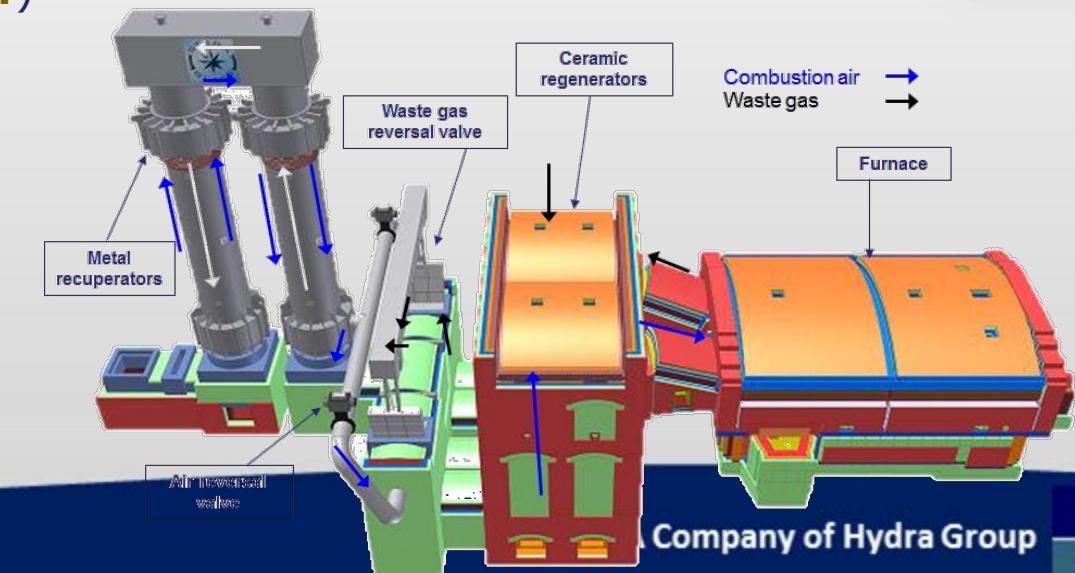
The high precision of Stara Glass design tools allowed the specialists to develop different hybrid heat recovery systems that maximize the benefits of regenerative / recuperative and ceramic / metal technologies.

Centauro system (see also the dedicated presentation) is a hybrid regenerative/recuperative glass furnace that guarantees at least the performance of a well dimensioned end-port furnace with some additional **advantages**:

- Flexibility in lay-out
- Reduced depth of regenerators
- **SNCR system**
- 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**)



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



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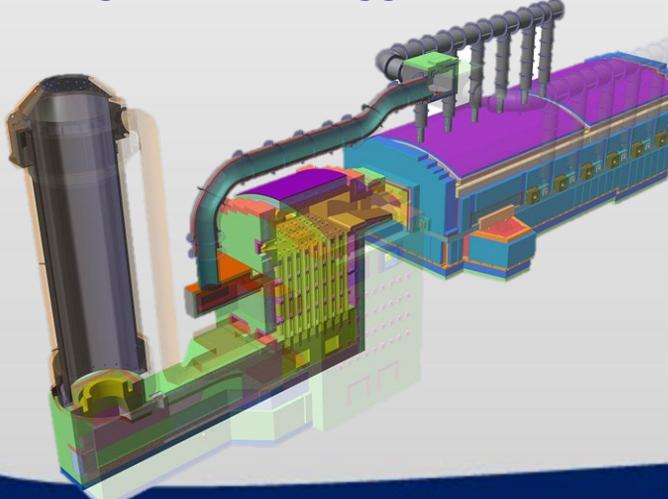


Hybrid glass furnaces: Minotauro and Ciclope

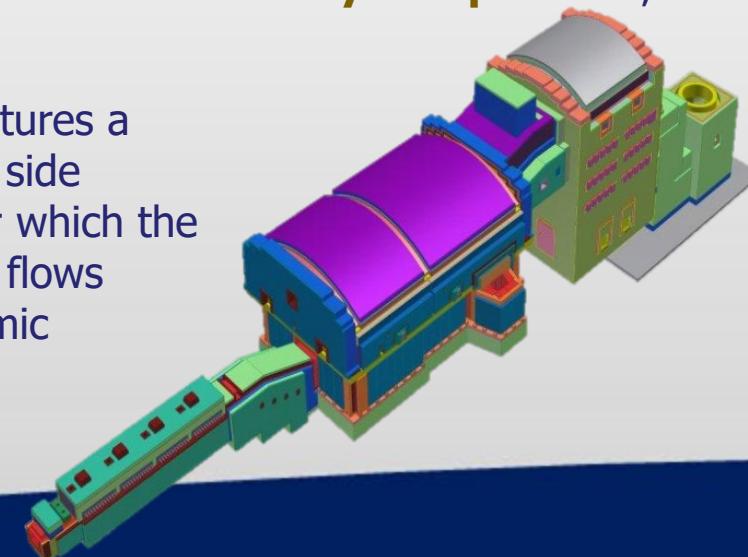
The high precision of Stara Glass design tools allowed the specialists to develop different hybrid heat recovery systems that maximize the benefits of regenerative / recuperative and ceramic / metal technologies.

Minotauro and Ciclope systems are hybrid solutions dedicated to the **borosilicate glass** production. Instead of the traditional high-performance unit melter furnaces, whose metal recuperators are constituted by a hot-stage tube-nest recuperator and a cold-stage double-shell recuperator, the hot-stage is here constituted by a **continuous cross-flow ceramic recuperator**, with few important features:

- Flexibility in lay-out
- **Pre-heated air temperature up to 950-1050°C** instead of the UM 700-800°C level with a related important energy saving
- The system is dimensioned to have **most of the borate condensation happening in the robust and cleanable refractory duct that connects ceramic and metal heat recovery components**, thus limiting the problems due to the high chemical aggression of the compounds.



Minotauro features a unit-melter-like side combustion, for which the 900-1000°C air flows through a ceramic distributor



Ciclope utilizes an M-shaped flame by installing a single waste gas duct and two continuously operating air ports.

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Advanced systems for NOx containment

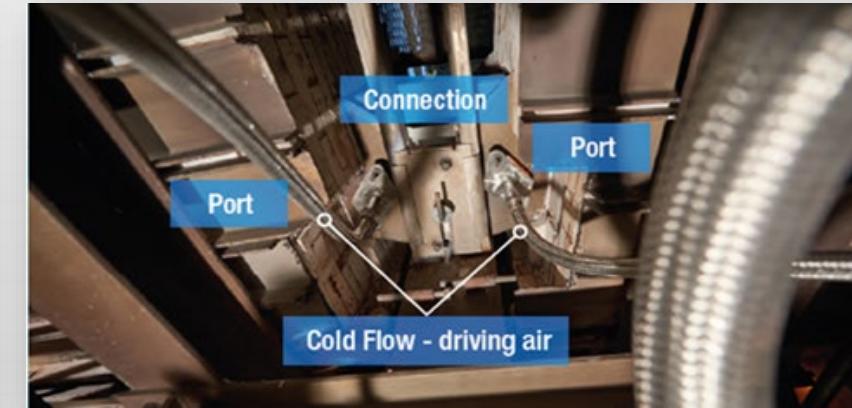
Stara Glass, thanks to its deep involvement in R&D activities, has developed 3 systems for NOx containment, that we offer together with our expert combustion management service (*see the dedicated presentations*).

Primary abatement

- Strategic waste gas recirculation: up to -35% NOx field results
- High-efficiency air-staging: up to -40% NOx field results

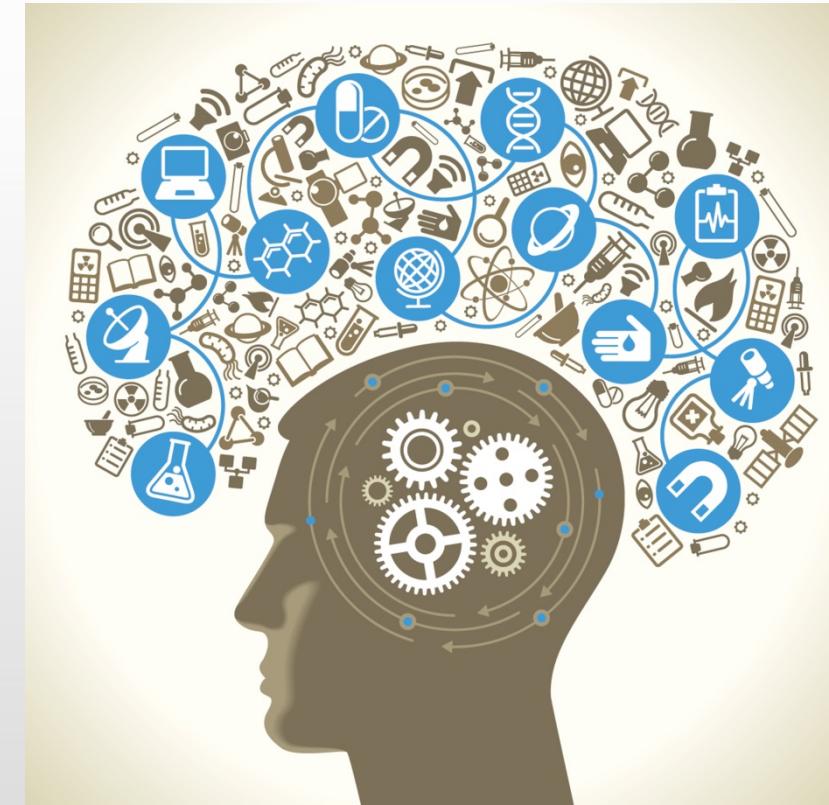
Secondary abatement

- SNCR system for Centauro furnace: up to -85% NOx field results





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Financed research projects: Prime Glass

Stara Glass aims at standing at the forefront of the glass production research, with the constant goals of lowering pollution and consumption, in order **to make glass industry more and more sustainable**. For this, we have been and we are involved in many research projects.

The **Prime Glass LIFE project**, **LIFE12 ENV/IT/001020** – www.primeglass.it – in which Stara Glass coordinated Stazione Sperimentale del Vetro and the University of Genoa allowed us to develop the technologies of Strategic waste gas recirculation and High-efficiency air-staging.

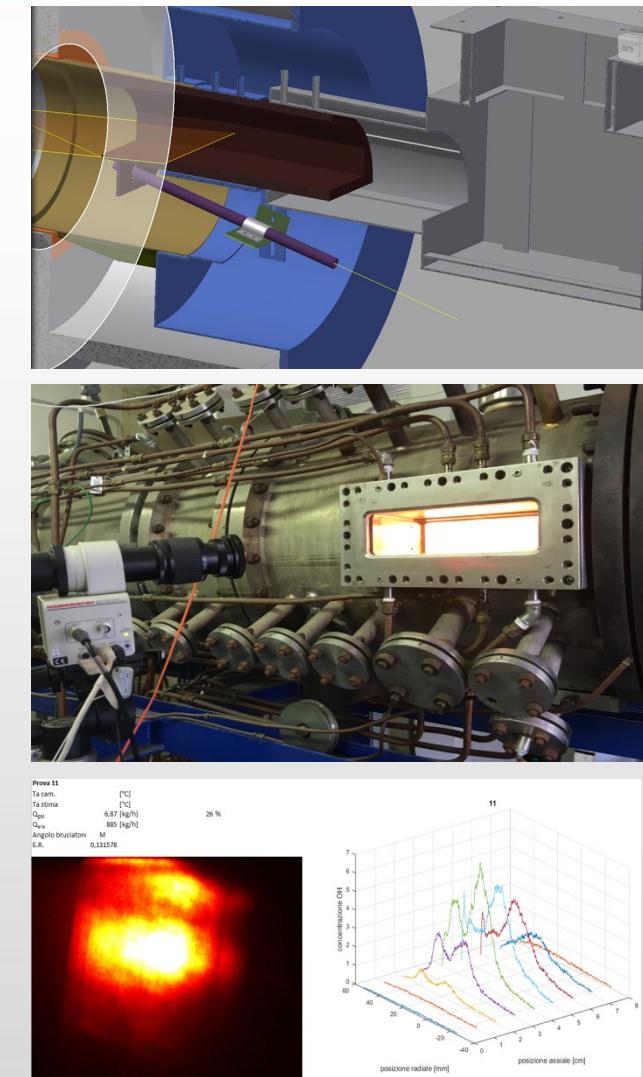




Financed research projects

In the last 15 years, Stara Glass took part to many research projects, including:

- **IPS - FILSE HUMMING** - Control and detection of thermo-acoustic instability in power gas turbines: in this wide range project, Stara Glass co-operates with Ansaldo Energia, Tirreno Power and again with Università degli Studi di Genova and Consorzio SI.RE. to develop mathematical models and measurement and control systems for high and very high temperature combustion optimization in different industrial fields
- **RECAVE** - Advanced Heat Recovery in Glass Furnaces, with Consorzio SIRE (Dynamic simulation and Virtual Reality). Starting from a detailed study about regeneration chambers optimization, Stara Glass started an important cooperation with a remarkable reality of CFD, resident in Savona University
- **SEMPRE** - Development of design methods and new technological solutions aimed at increasing energy recovery in complex plants: early experimentation performed in the glass industry, with the partners: CETMA (Brindisi), ENEA (Faenza), Neubor Glass (San Vito al Tagliamento - PN)
- **CORE** - Development of new components conceived to increase plant thermal efficiency and life in glass furnaces, in cooperation with the partner Ansaldo Ricerche (Genoa)
- **PUMA** - (Progetto Unit Melter Avanzati – Advanced Unit Melter Design), with the partners: Ansaldo Ricerche (Genoa), CETMA (Brindisi), ENEA (Faenza), Scandiuzzi SUD (Brindisi), Saint Gobain Vetri (Gazzo Veronese - VR)
- **FILSE PAR FAS 16 project** – Energy and ambient optimization of the glass melting process, with the partners: Area Genovese and Ri.Me.Bo.





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Patents

Stara Glass owns few Italian and international patents, the main are:

- **Centauro** - IT1386349 / WO 2009/093134
- **High-efficiency air-staging** - IT1408494
- **Strategic waste gas recirculation** - IT1414478
- *Coming soon...*





Stara Glass – More than 60 years of high performance

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