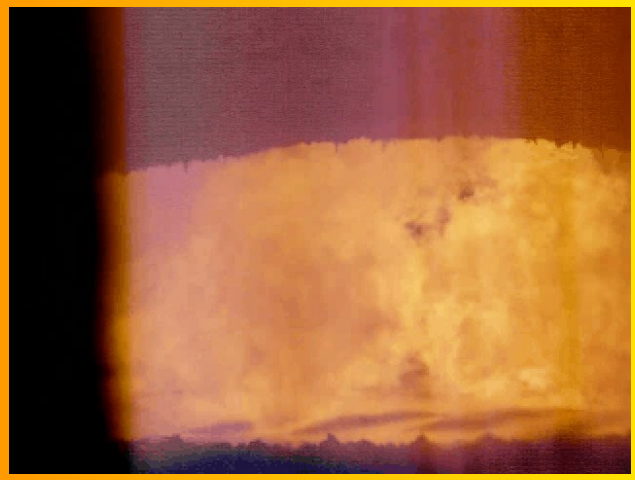
Executive Committee Meeting of the All India Glass Manufacturers Federation



15 DECEMBER 2012

FIROZABAD – INDIA

FT BURNERS

PRACTICAL APPLICATION RESULTS OF NEW GAS BURNER IN FLOAT, CONTAINER AND TABLEWARE GLASS INDUSTRY

Contents of Presentation

- Introduction and history
- FT burner design and operating principles
- FT burner design and simulation
- Installation
- Production results
- Benefits

Optimized natural gas combustion process

- Furnace design
- Regenerator design
- Technology level
- Control system level
- Batch composition
- Combustion system design especially burner design

The new situation in the world reflecting the economy and strong ecological request

- Increasing price of combustion oil
- Very strong ecological limits and higher penalties
- Growing interest in use of natural gas in glass furnaces
- NOx production
- Conversion from oil combustion to gas firing
- New and advanced burner system FLAMMATEC™ FLEX

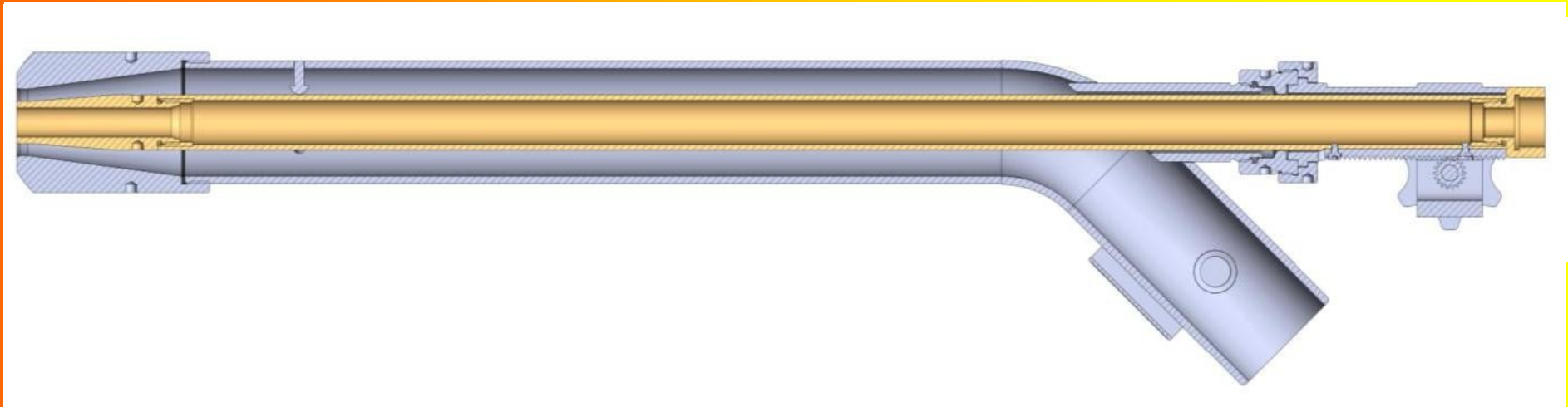
History of Dual Gas Injector Burners

- Dual gas injector burners are not a new technology and have been known since at least the 1960's.
- This concept was used by Corning and had two (2) concentric pipes with two (2) separate gas streams.
- Dual gas injector burner was broadly used in eastern Europe since 1970. The construction was simple without any optimization. The burner required two (2) gas inlets with different pressure.
- 1968 GAZ de France published their Twin Gas burner.
- A similar burner was used by Tokyo Gas in 2008.
- Other burner manufacturers introduced additional burners in the late 1990's. These burners had only one (1) gas inlet with the two (2) gas streams separated inside the burner.

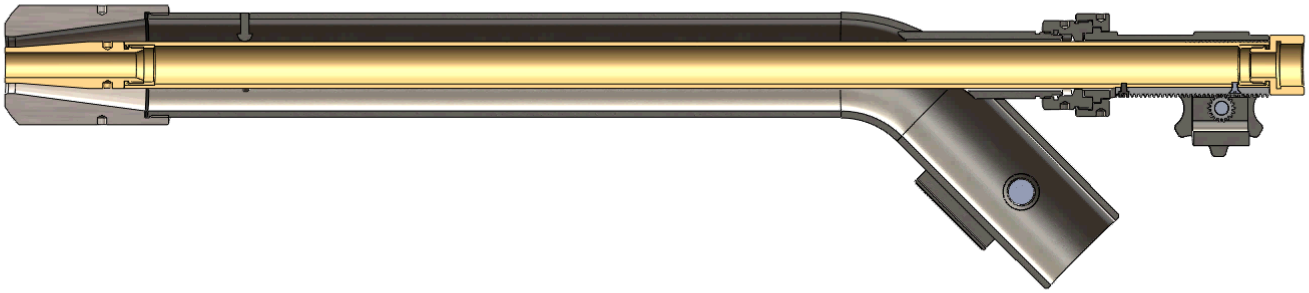
History of Dual Gas Injector Burners

- The common feature of all of these burners is that the gas enters the burner by only one (1) pipe with the second gas stream separated inside the burner.
- Advantages of a new burner concept were developed for the FlammaTec burner in 2006/2007.
- FlammaTec utilizes a complete two (2) gas stream concept with new advanced features such as:
  - Two (2) fully separate gas flows and control and measurement
  - Adjustable burner nozzle
  - Optimized burner tip
- Practical results confirm the newly advanced burner concept with a technical advantage.

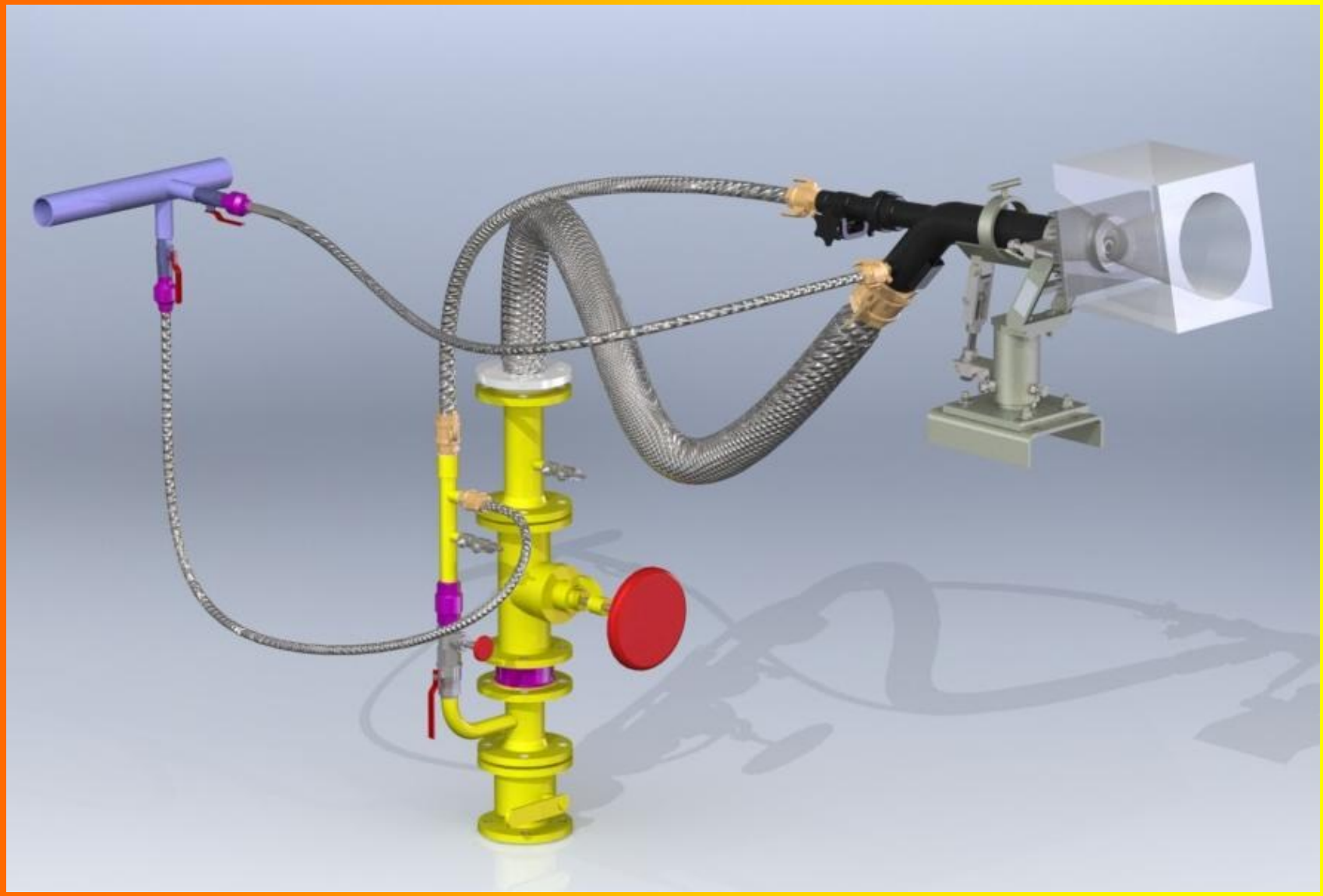
BURNER SCHEME



BURNER SCHEME



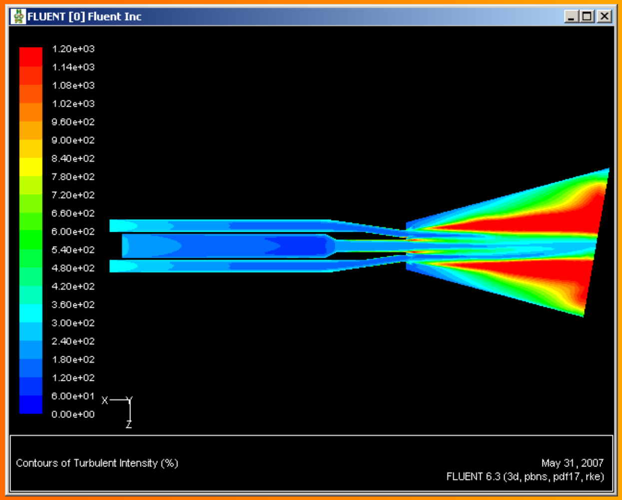
FT BURNER DESIGN AND OPERATING PRINCIPLES

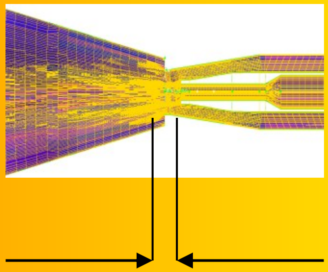


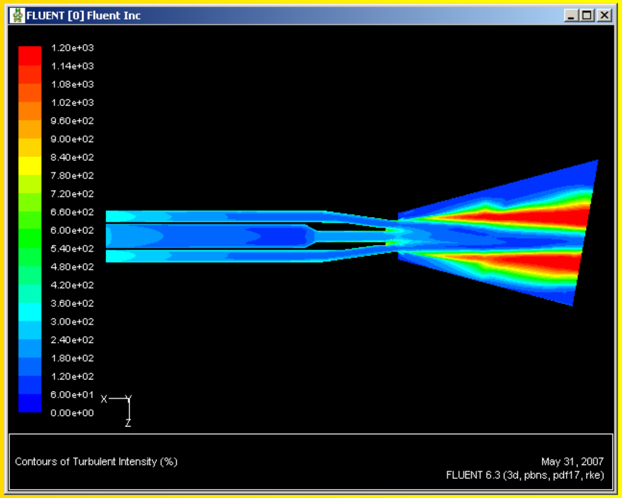
Underport burner

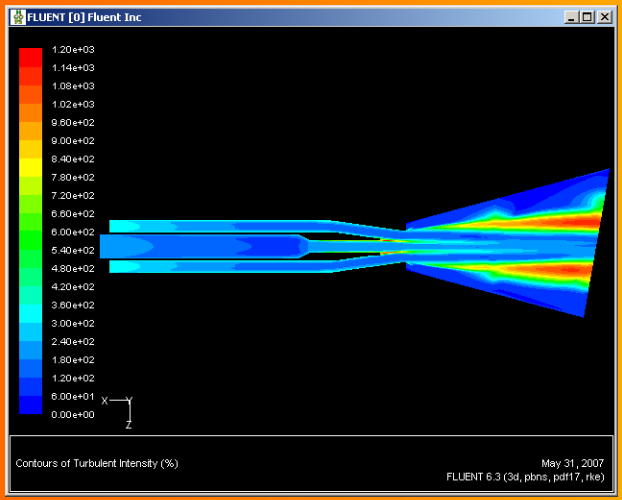
FT Design Optimized by Computer Modeling

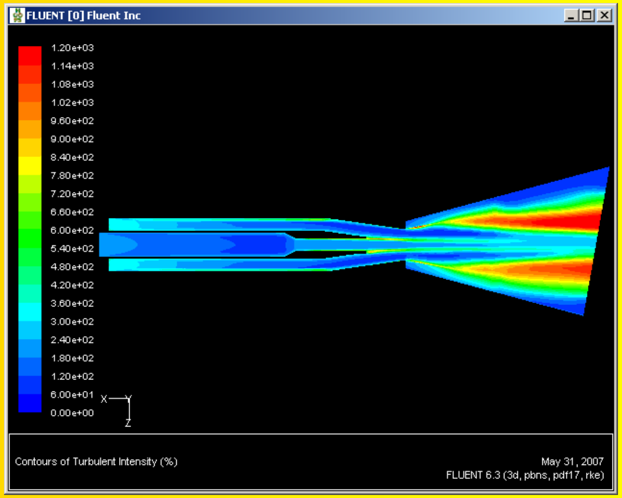
Turbulence optimization







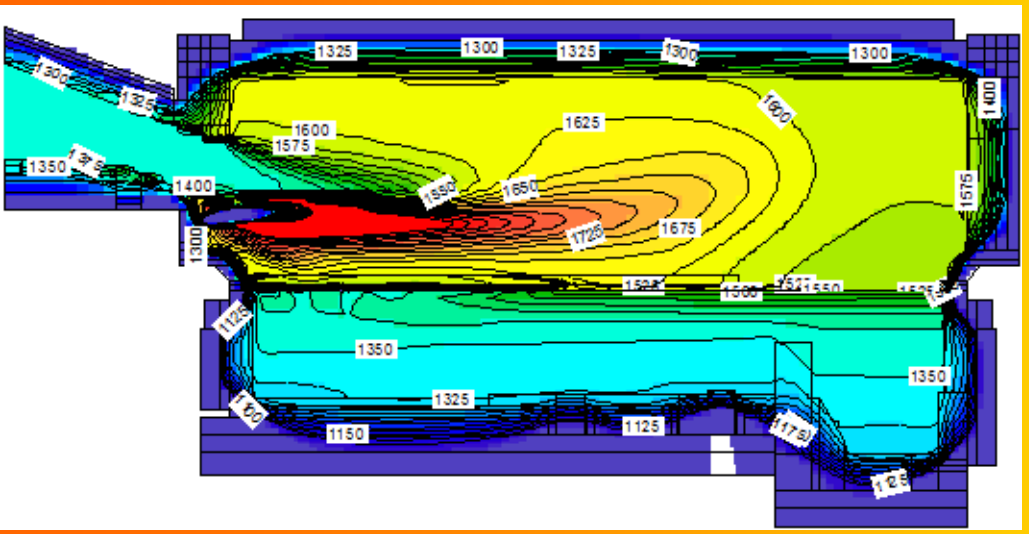




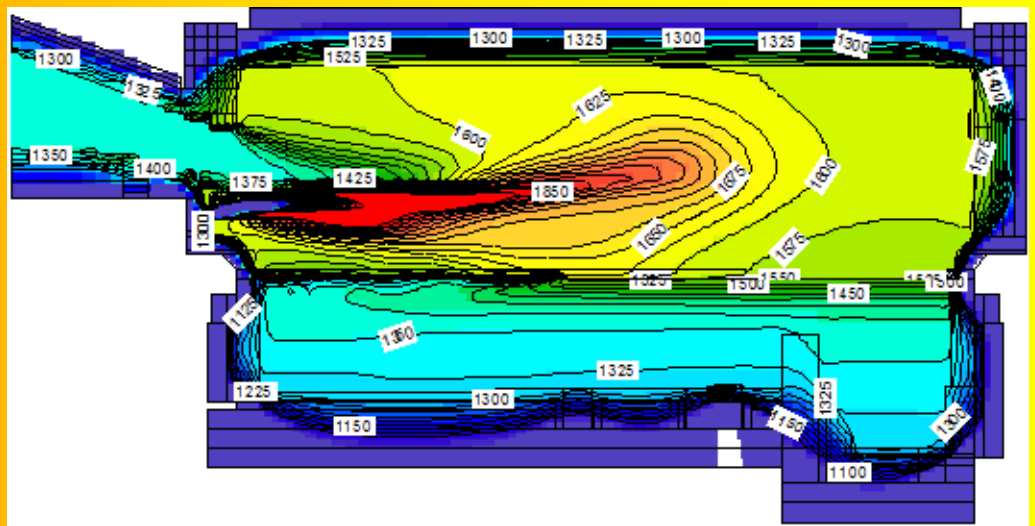
FT Design Optimized by Computer Modeling

Flame temperature

FlammaTec burner



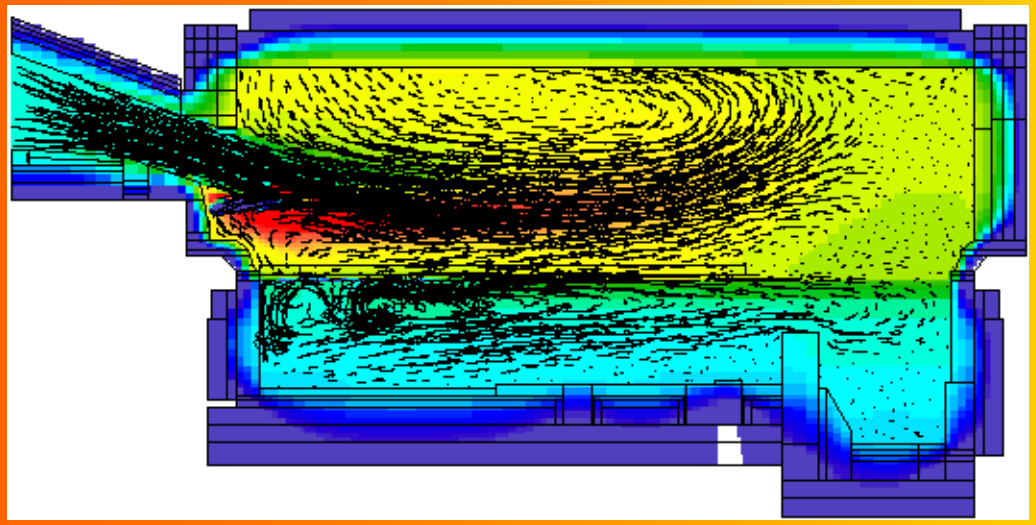
Conventional burner



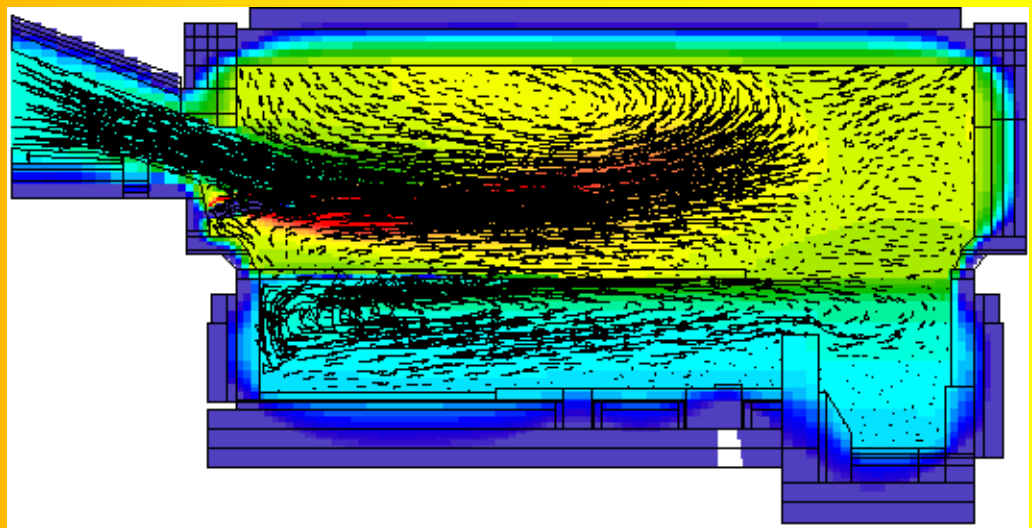
FT Design Optimized by Computer Modeling

Flame velocity

FlammaTec burner

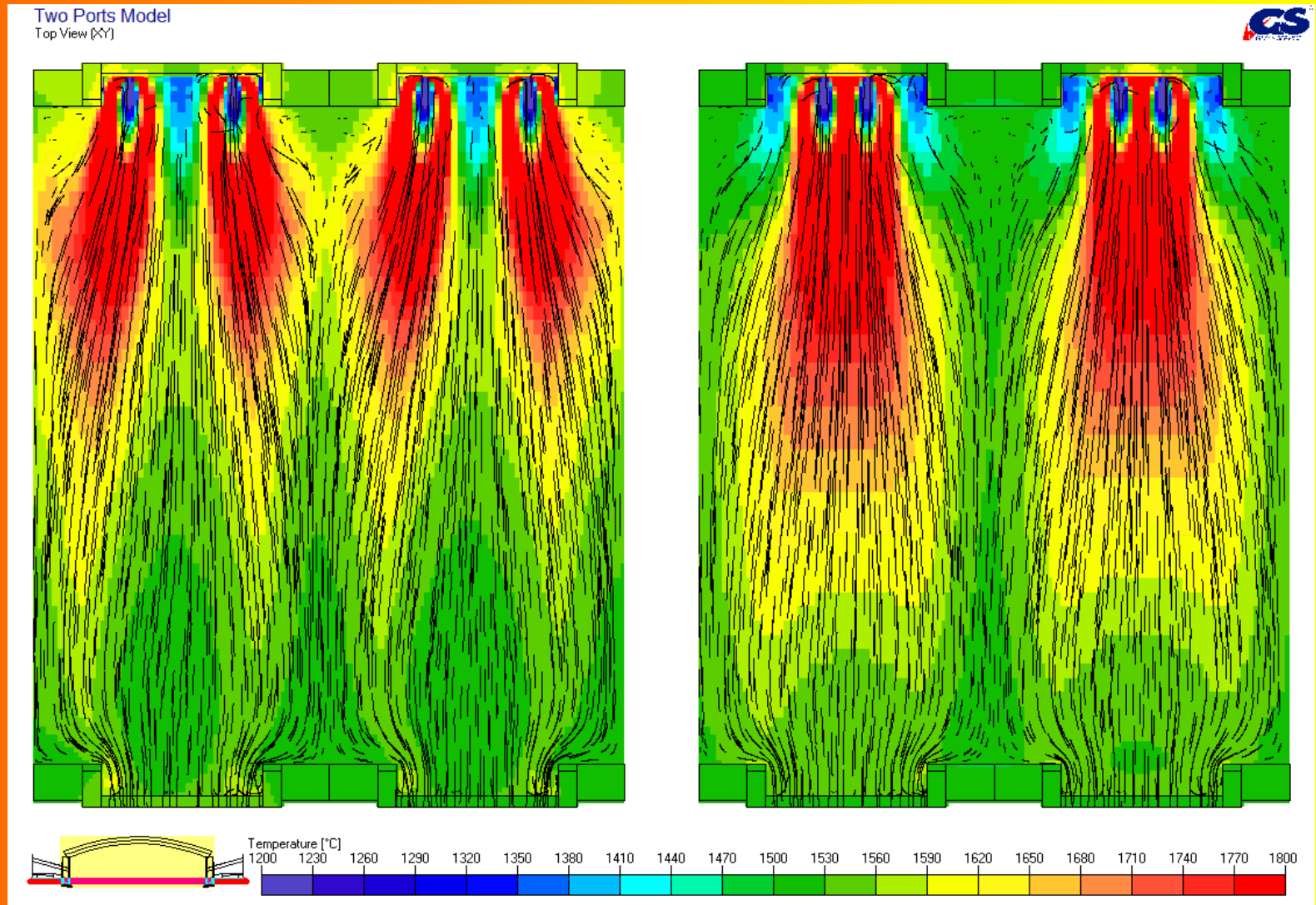


Conventional burner



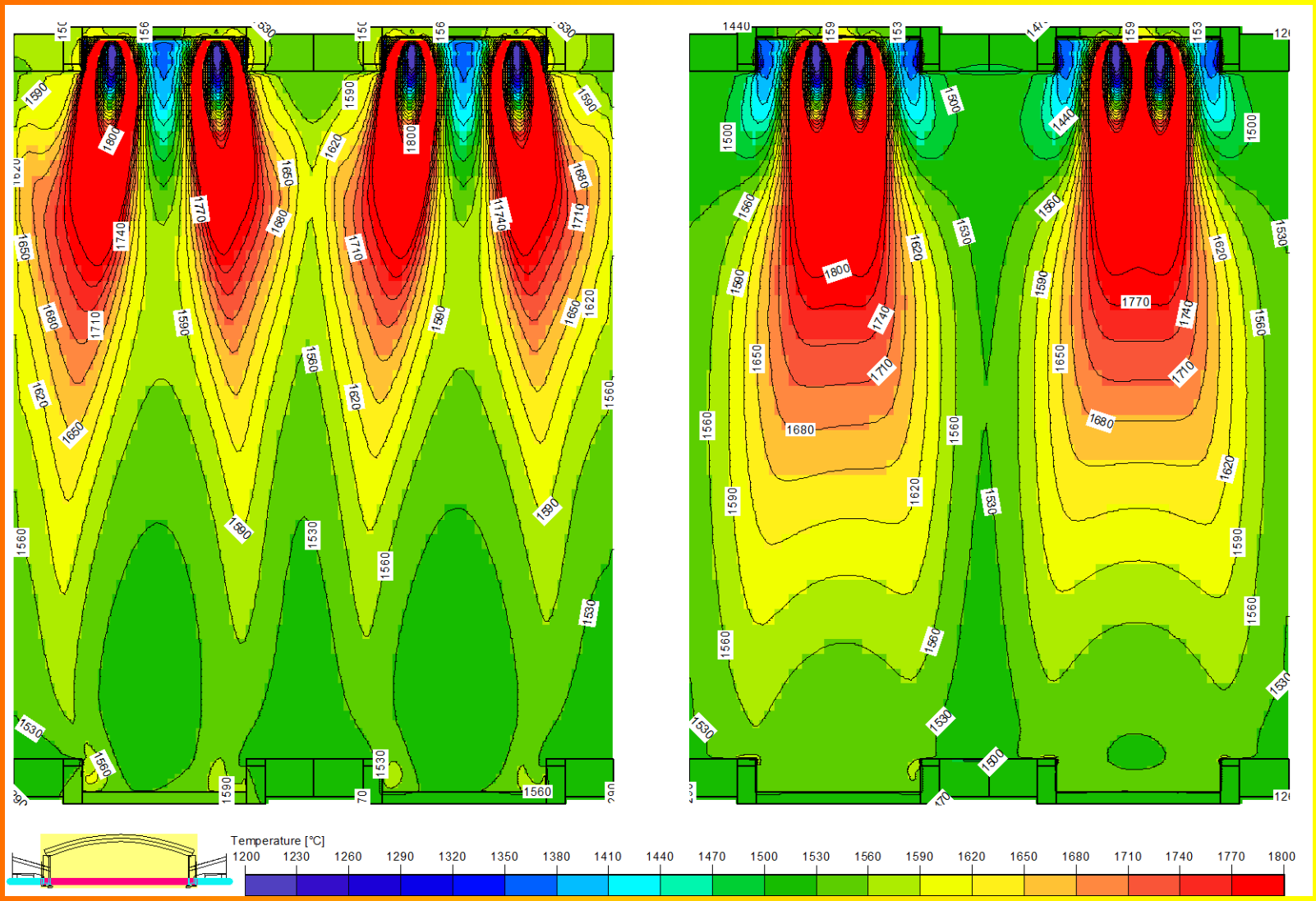
FT Design Optimized by Computer Modeling

Optimum burner block location

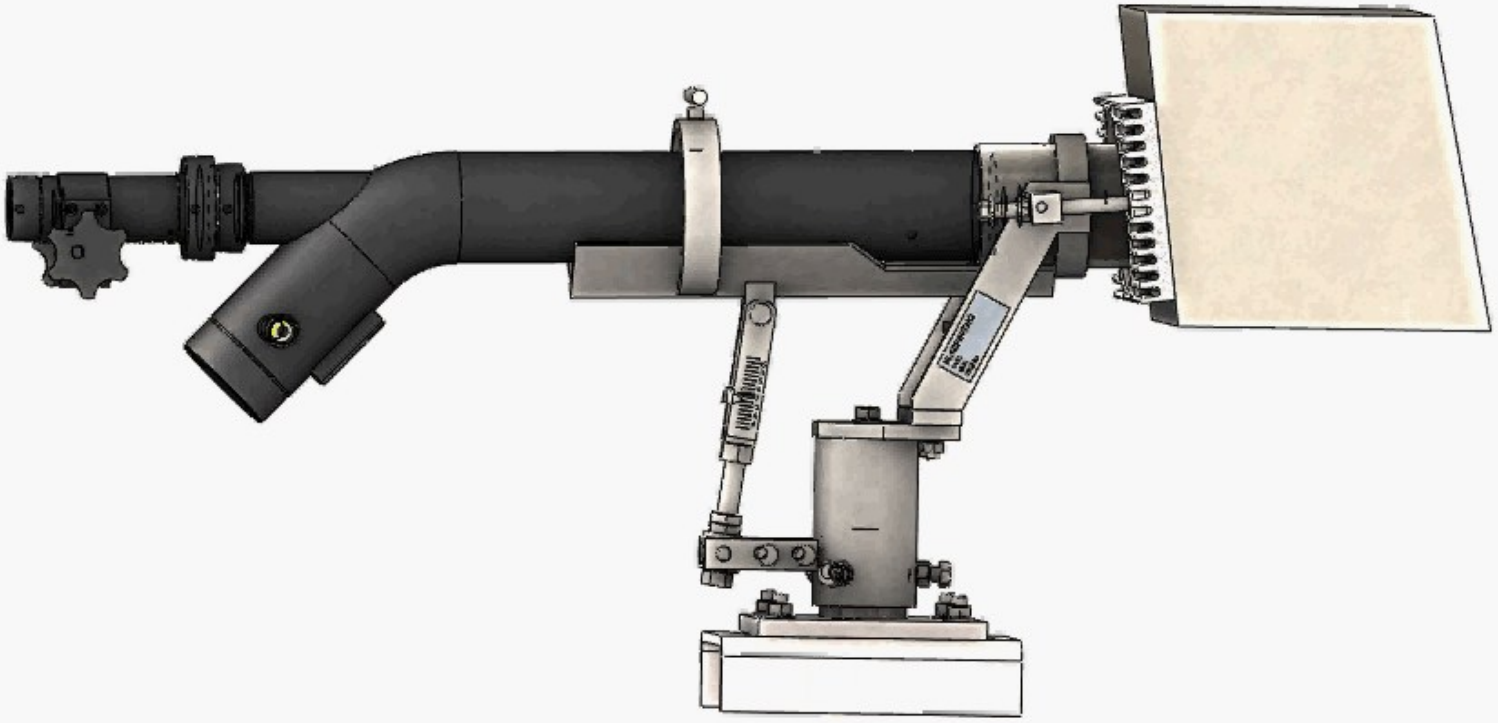


FT Design Optimized by Computer Modeling

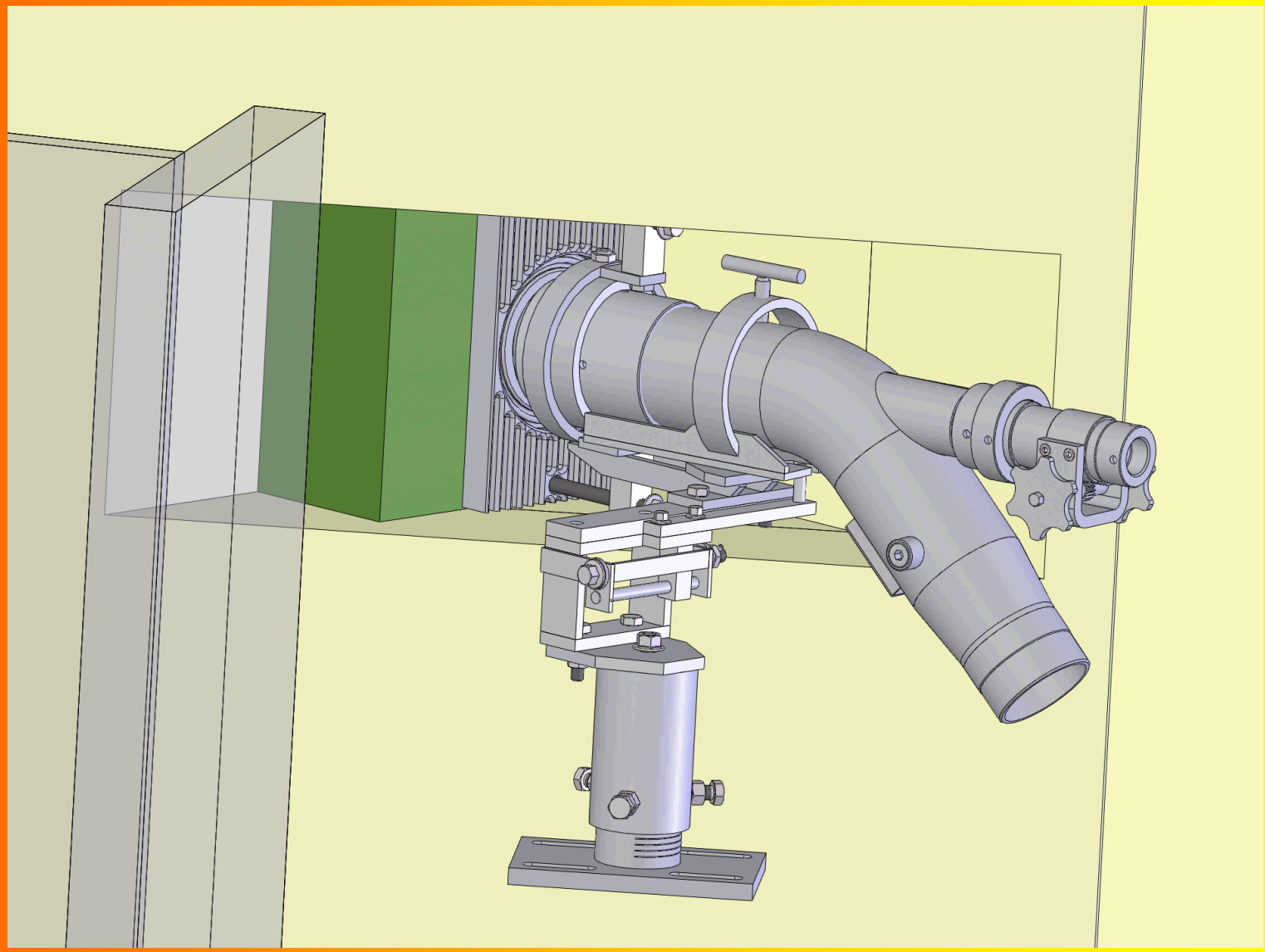
Optimum burner block location



FT BURNER INSTALLATION – UNDERPORT VERSION

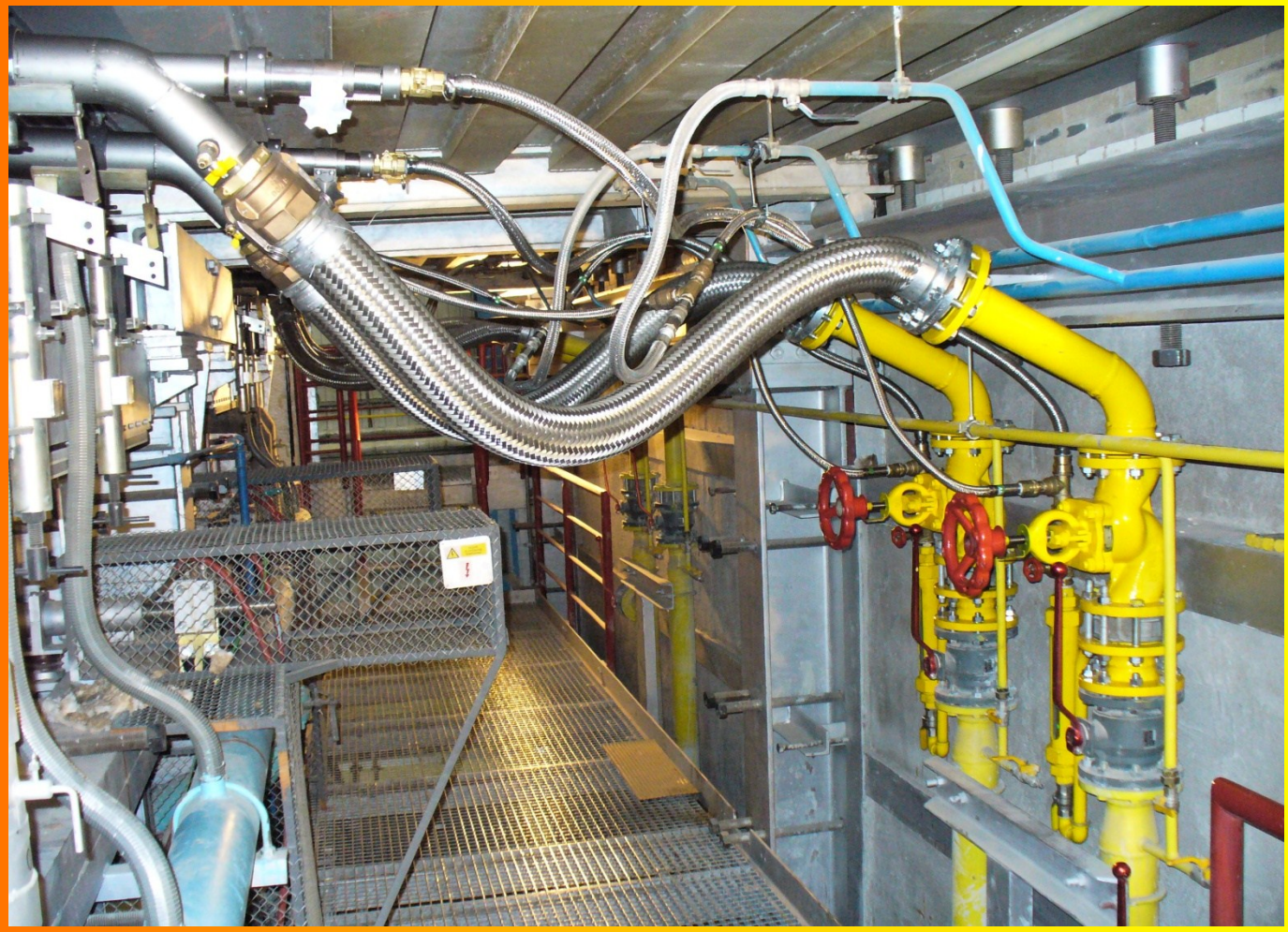


FT BURNER INSTALLATION – SIDEPORT VERSION



FT BURNER INSTALLATION

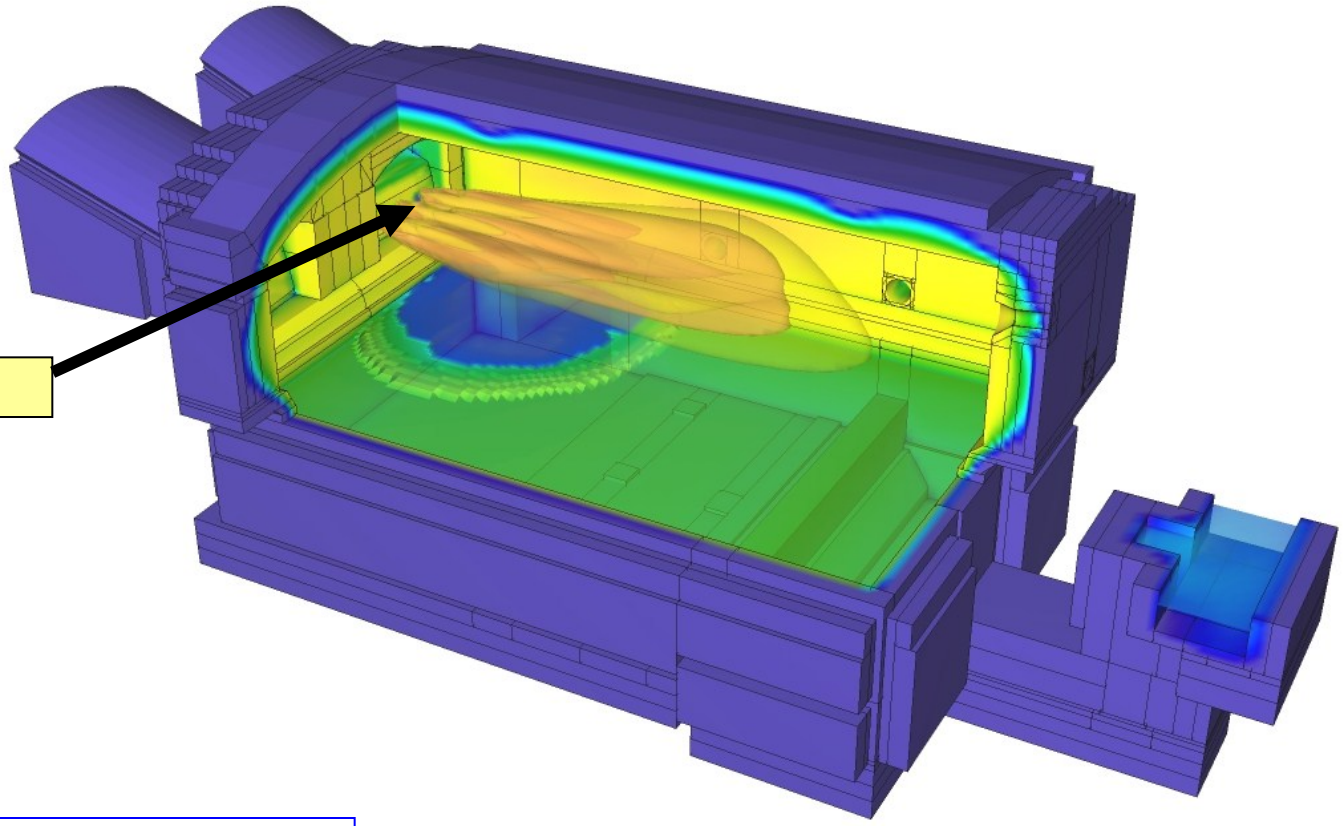
FT BURNER INSTALLATION



FT BURNER INSTALLATION

Furnace type : tableware
Glass type: SODA – LIME Glass
Pull: 100 MTPD
Cullet: 23 %

Total gas consumption : 648 Nm3/h
Heat value of gas : 10390 kcal/kg
Combustion heat : 6029 KW



Melter area : 34.2 m2
Glass depth melter: 1245 mm
Spec. pull : 2.92 MTPD/m2
Spec. energy consumption: 5.209 MJ/kg

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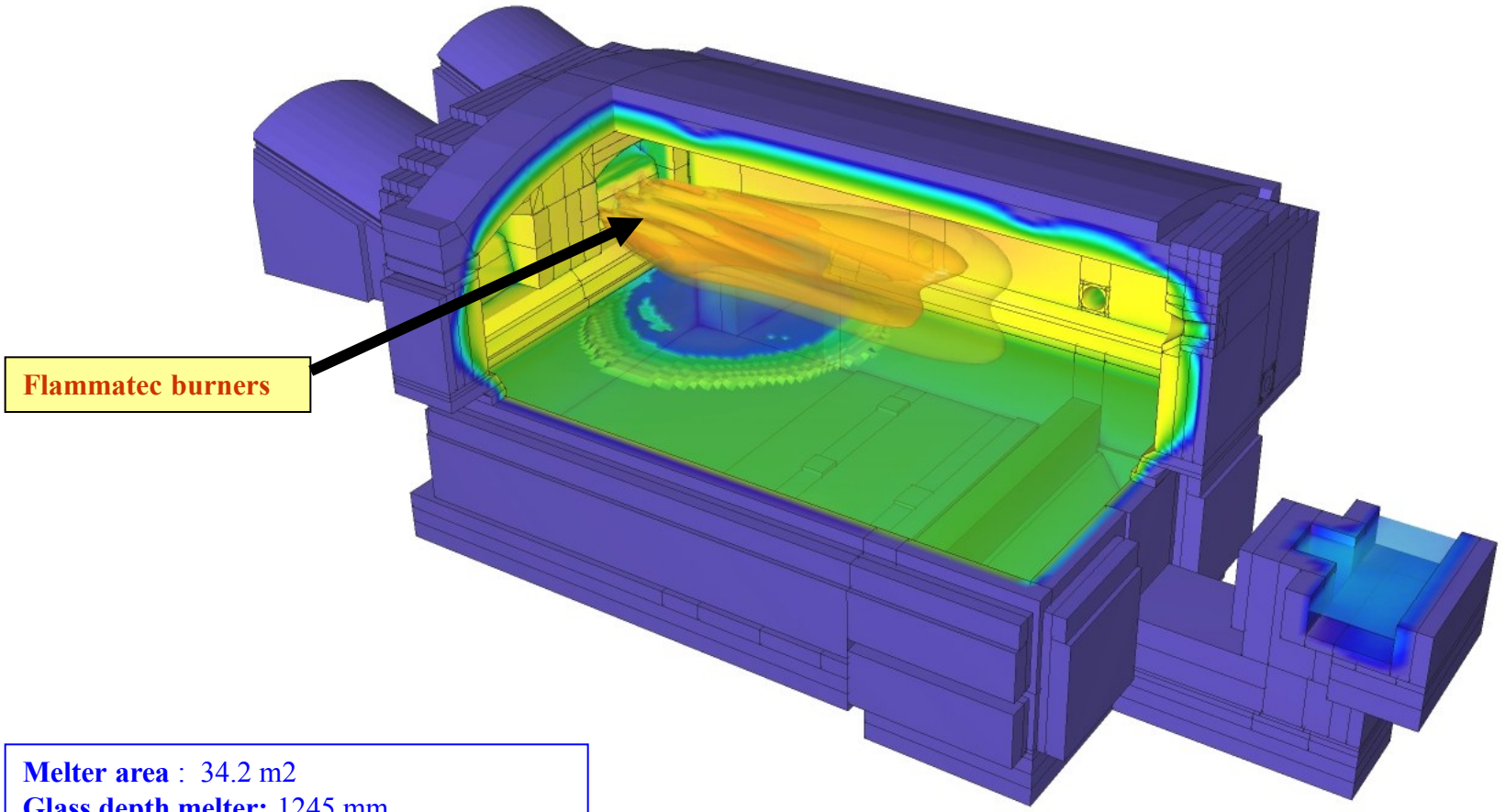
FT BURNER INSTALLATION

Furnace type : tableware
Glass type: SODA – LIME Glass
Pull: 100 MTPD
Cullet: 23 %

Total gas consumption : **612,3** Nm3/h
Heat value of gas : 10390 kcal/kg
Combustion heat : **5697** KW

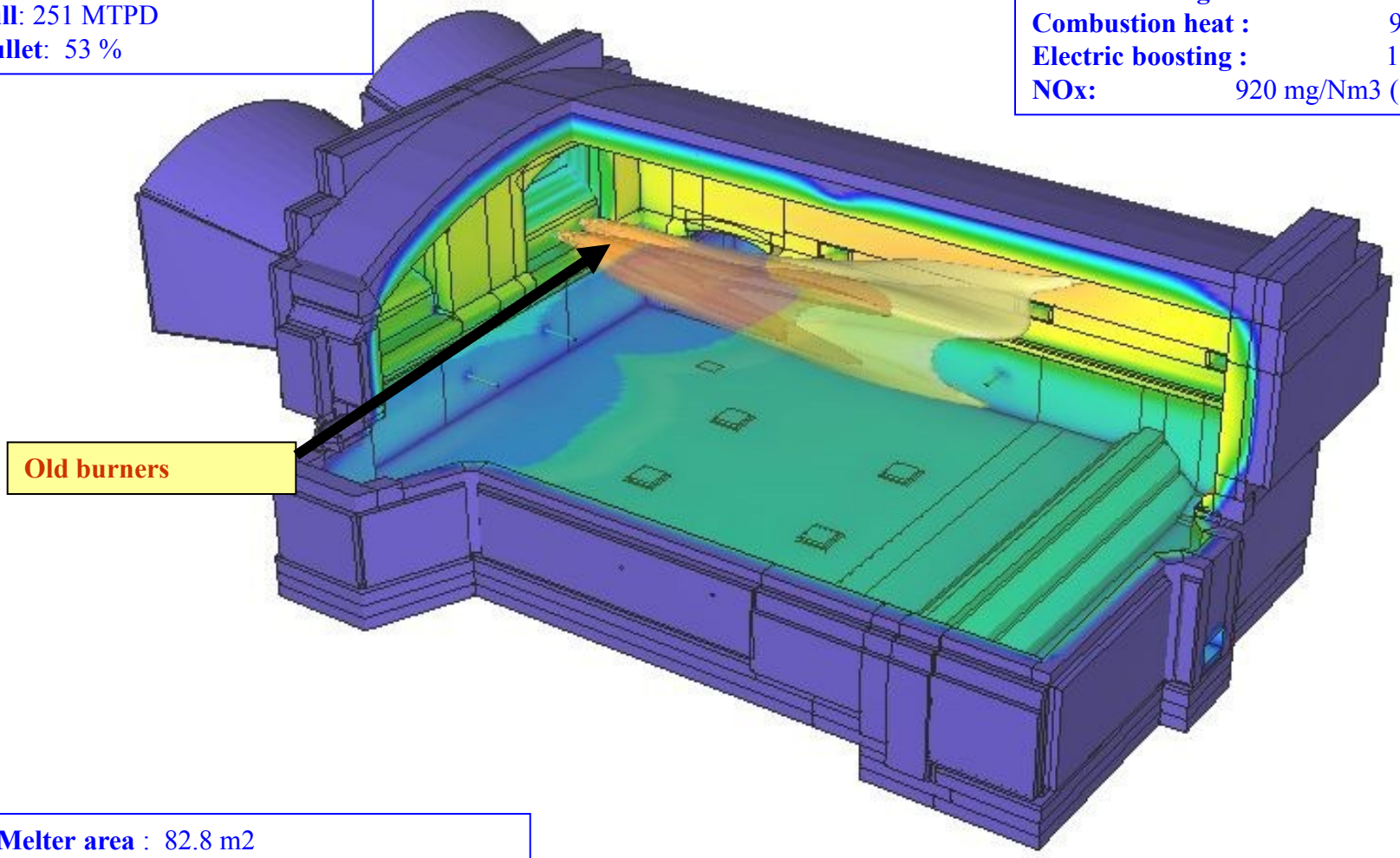


Melter area : 34.2 m2
Glass depth melter: 1245 mm
Spec. pull : 2.92 MTPD/m2
Spec. energy: **4.922** MJ/kg

FT BURNER INSTALLATION

Furnace type : container
Glass type: green
Pull: 251 MTPD
Cullet: 53 %

Total gas consumption : 1005 Nm3/h
Heat value of gas : 11192 kcal/kg
Combustion heat : 9550 kW
Electric boosting : 1082 kW
NOx: 920 mg/Nm3 (8% O2)

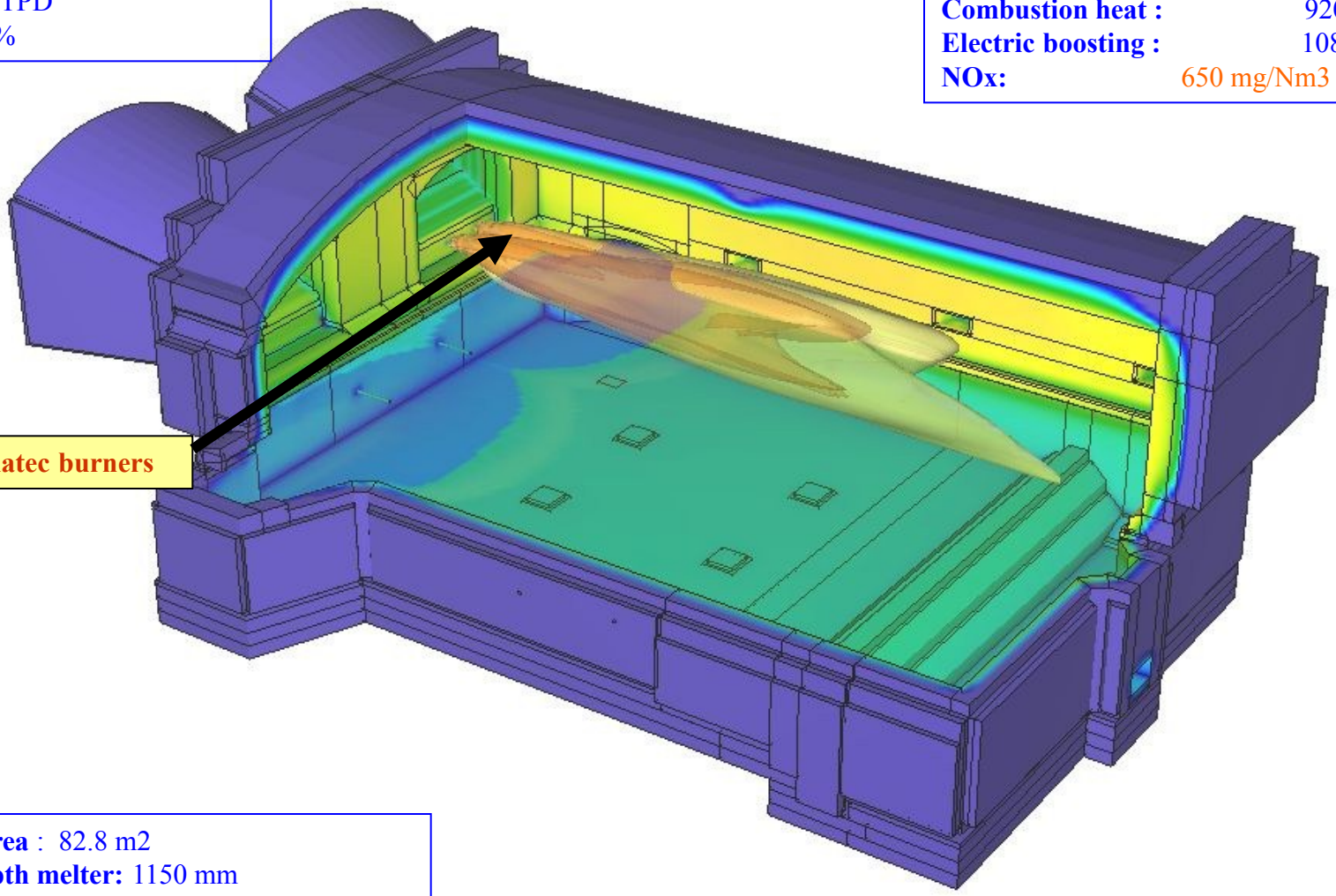


Melter area : 82.8 m2
Glass depth melter: 1150 mm
Spec. pull : 3.03 MTPD/m2
Spec. energy consumption: 3.66 MJ/kg

FT BURNER INSTALLATION

Furnace type :container
Glass type: green
Pull: 251 MTPD
Cullet: 53 %

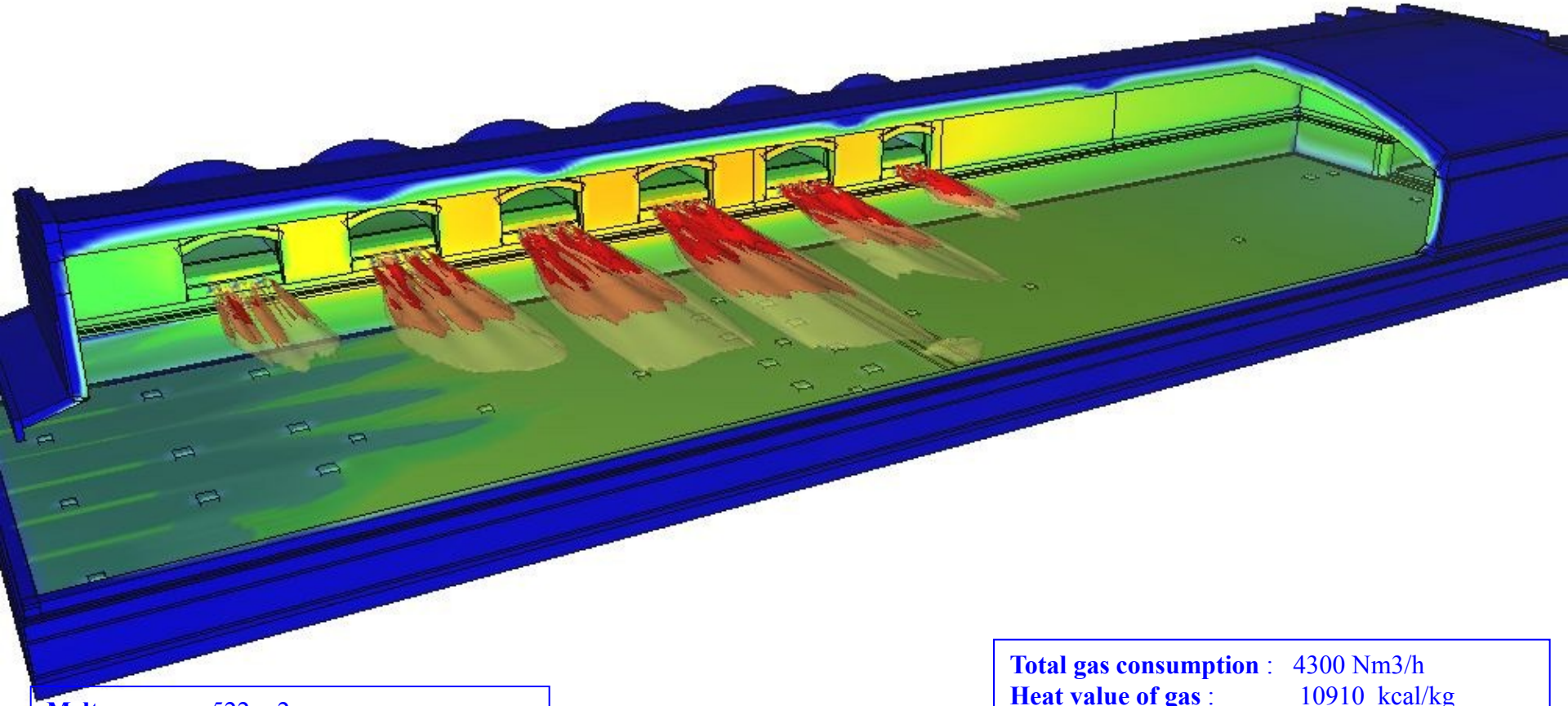
Total gas consumption : 968 Nm3/h
Heat value of gas : 11192 kcal/kg
Combustion heat : 9201 kW
Electric boosting : 1082 kW
NOx: 650 mg/Nm3 (8% O2)



Melter area : 82.8 m2
Glass depth melter: 1150 mm
Spec. pull : 3.03 MTPD/m2
Spec. energy consumption: 3.54 MJ/kg

FT BURNER INSTALLATION

Furnace type : Float
Glass type: white
Pull: 700 MTPD
Cullet: 30 %

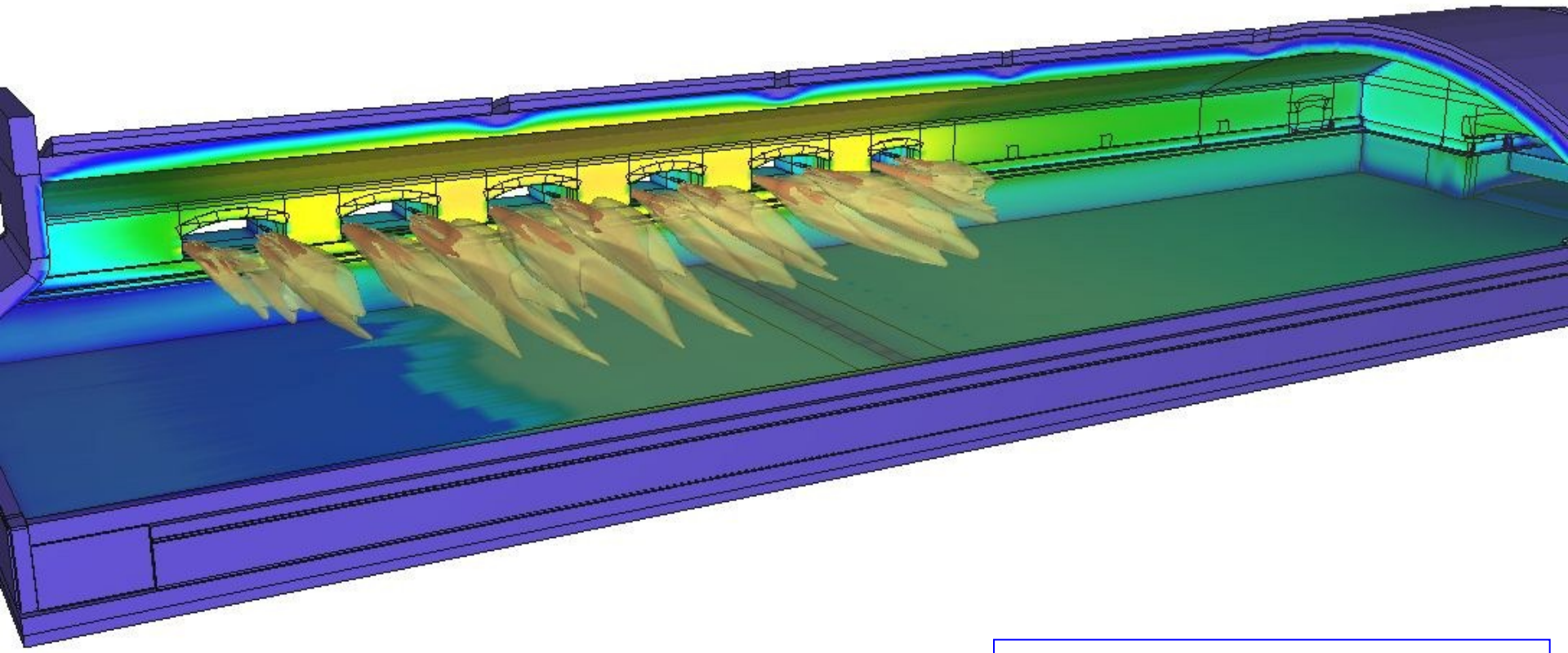


Melter area : 522 m2
Glass depth melter: **1325** mm
Spec. pull : **1,34** MTPD/m2
Spec. energy consumption: **5,18** MJ/kg

Total gas consumption : 4300 Nm3/h
Heat value of gas : 10910 kcal/kg
Combustion heat : 41939 kW
NOx: **< 1500** mg/Nm3 (8% O2)

FT BURNER INSTALLATION

Furnace type : Float
Glass type: white
Pull: 650 MTPD
Cullet: 25 %



Melter area : 520 m2
Glass depth melter: 1250 mm
Spec. pull : 1,25 MTPD/m2
Spec. energy consumption: 5,64 MJ/kg

Total gas consumption : 4744 Nm3/h
Heat value of gas : 10455 kcal/kg
Combustion heat : 44342 kW
NOx: 1950 mg/Nm3 (8% O2)

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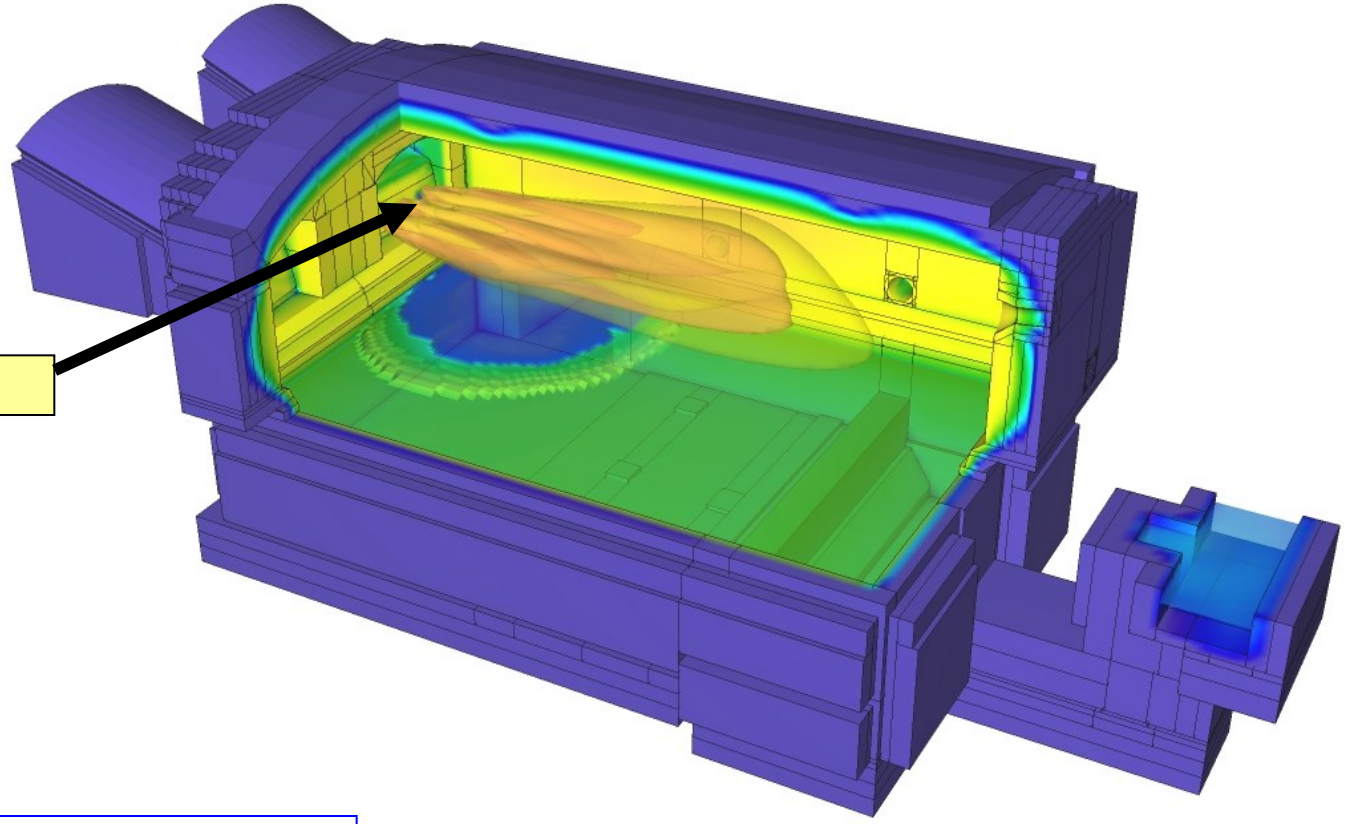
FT BURNER INSTALLATION

Furnace type : tableware
Glass type: white
Pull: 85 MTPD
Cullet: 15 %

Total gas consumption : 543 Nm3/h
Heat value of gas : 10390 kcal/kg
Combustion heat : 5052 kW
NOx : 2375 mg/m3 (8%O2)



Melter area : 53 m2
Glass depth melter: 1150 mm
Spec. pull : 1.6 MTPD/m2
Spec. energy consumption 5135 MJ/kg

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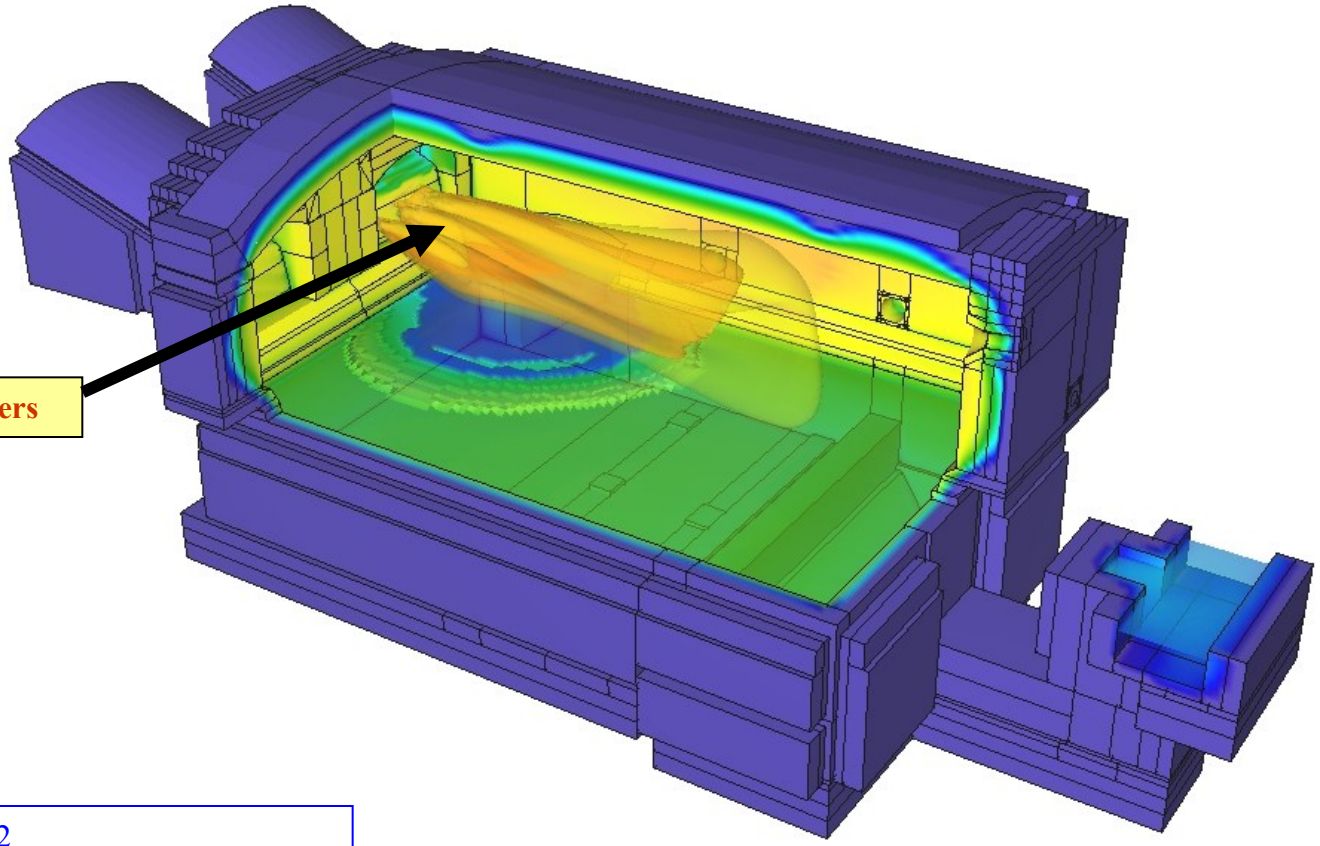
FT BURNER INSTALLATION

Furnace type : tableware
Glass type: white
Pull: 85 MTPD
Cullet: 15 %

Total gas consumption : 514 Nm3/h
Heat value of gas : 8000 kcal/kg
Combustion heat : 4782 kW
Nox : 1625 mg/m3 (8%O2)



Melter area : 53 m2
Glass depth melter: 1150 mm
Spec. pull : 1.6 MTPD/m2
Spec. energy consumption 4861 MJ/kg

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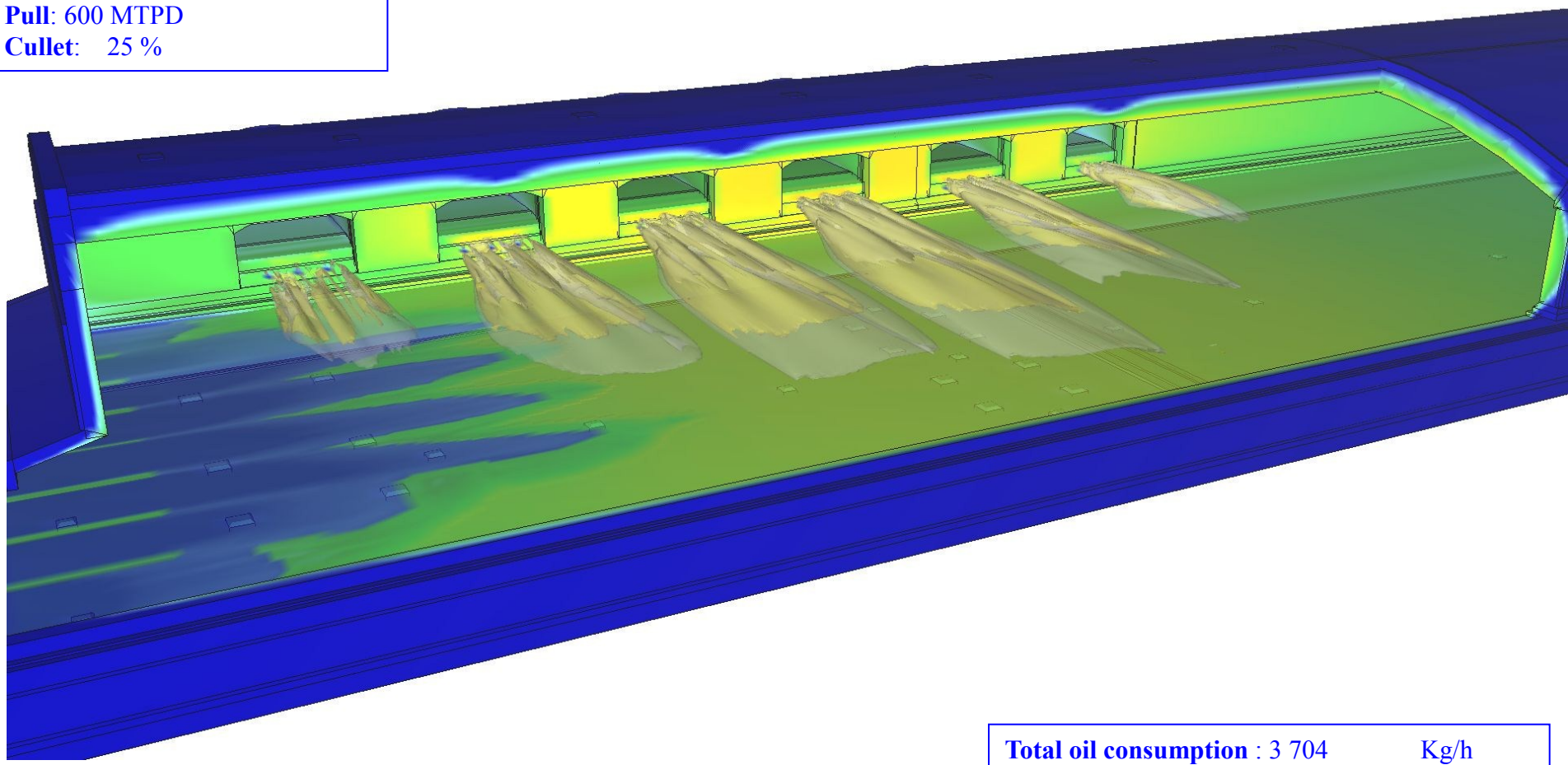
FT BURNER INSTALLATION

Furnace type : Float
Glass type: white
Pull: 600 MTPD
Cullet: 25 %



Melter area : 465 m2
Glass depth melter: **1280** mm
Spec. pull : **1,29** MTPD/m2
Spec. energy consumption: **5,62** MJ/kg

Total oil consumption : 3 704 Kg/h
Heat voile of oil : 10 525 kcal/kg

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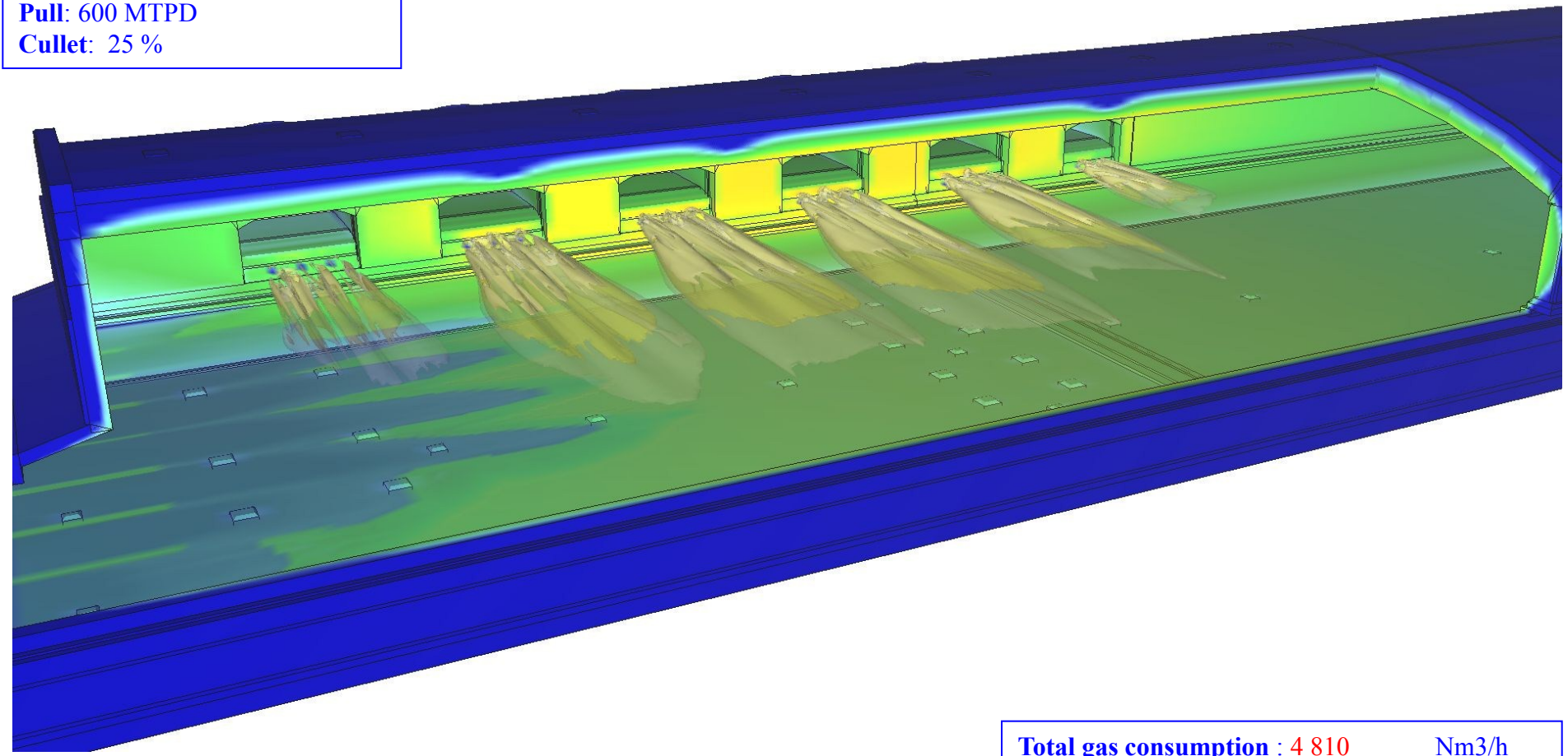
FT BURNER INSTALLATION

Furnace type : Float
Glass type: white
Pull: 600 MTPD
Cullet: 25 %



Melter area : 465 m2
Glass depth melter: 1280 mm
Spec. pull : 1,29 MTPD/m2
Spec. energy consumption: **5,62** MJ/kg

Total gas consumption : 4 810 Nm3/h
Heat value of gas : 9070 kcal/kg
NOx: **1 840** mg/Nm3 (8% O2)

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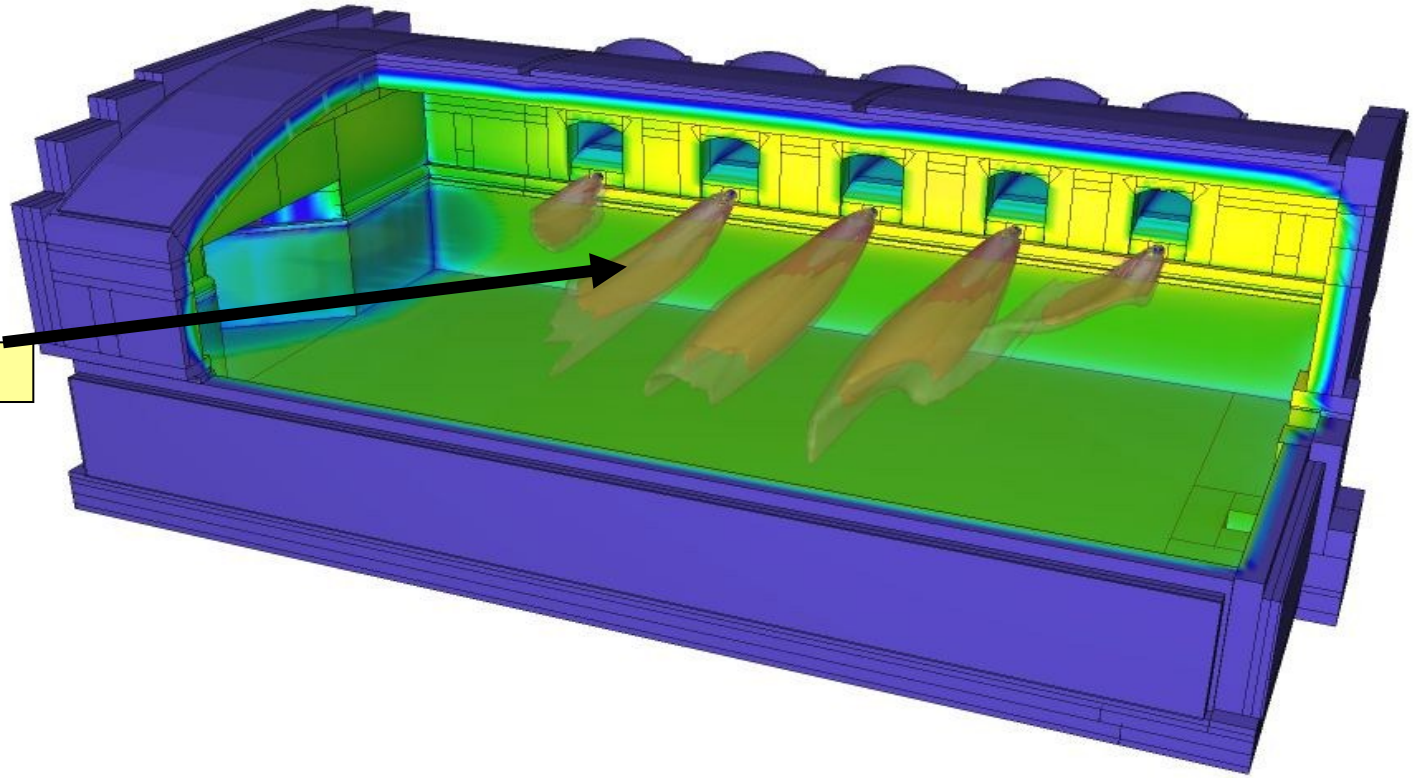
FT BURNER INSTALLATION

Furnace type : tableware
Glass type: soda-lime
Pull: 160 MTPD
Cullet: 28 %

Total gas consumption : 1096 Nm3/h
Heat value of gas : 11645 kcal/kg
Combustion heat : 10372 kW



Old burners

Melter area : 86,9 m2
Glass depth melter: 1448 mm
Spec. pull : 1,84 MTPD/m2
Spec. energy consumption 5597 MJ/kg

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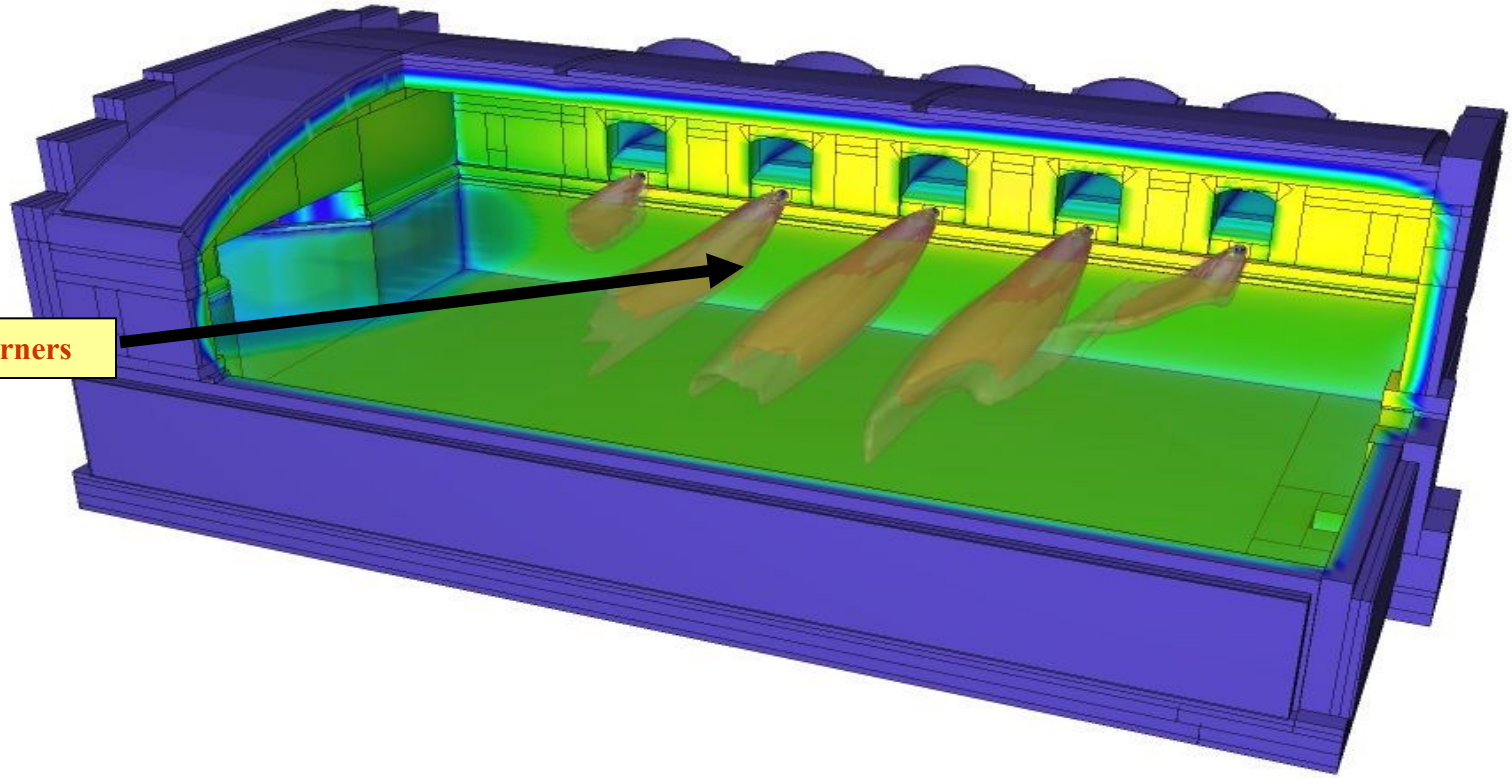
FT BURNER INSTALLATION

Furnace type : tableware
Glass type: soda-lime
Pull: 160 MTPD
Cullet: 28 %

Total gas consumption : 1061 Nm3/h
Heat value of gas : 11645 kcal/kg
Combustion heat : 10050 kW



Melter area : 86,9 m2
Glass depth melter: 1448 mm
Spec. pull : 1.84 MTPD/m2
Spec. energy consumption 5135 MJ/kg

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FT BURNER INSTALLATION - COMPARISON

	PREVIOUS BURNERS	FT BURNERS	DIFFERENCE
End fired furnace - tableware			
Total energy consumption Nm3/hr	648	612,3	5,51
Specific energy consumtion MJ/T	5 209	4 922	5,51
End fired furnace - container			
Total energy consumption Nm3/hr	1005	963	4,18
Specific energy consumtion MJ/T	3,66	3,54	3,28
End fired furnace - tableware			
Total energy consumption Nm3/hr	543	514	5,34
Specific energy consumtion MJ/T	5 135	4 861	5,34
Cross fired furnace – tableware			
Total energy consumption Nm3/hr	1096	1061	3,2
Specific energy consumtion MJ/T	5597	5135	3,2

The practical results fully confirmed the expected benefits

- flame is easy to tune from short turbulent shape up to a long low turbulent shape and highly luminous flame
- highly luminous stable flame is achieved
- batch melting was enhanced after a change to FLAMMATEC burner creating shorter batch piles
- bottom temperatures were visibly increased, allowing glass quality improvements and a fuel reduction

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