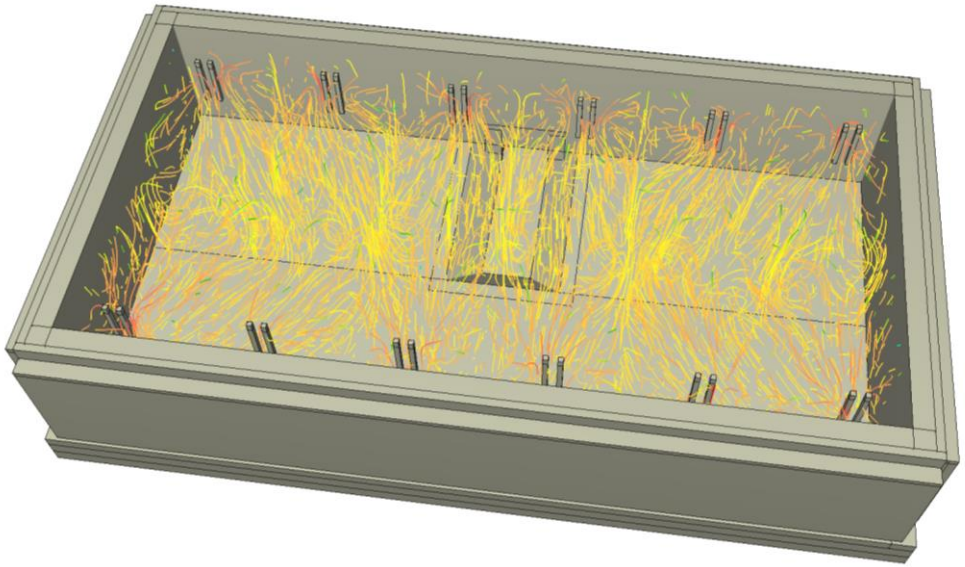
GLASS MELTING TECHNOLOGY

INNOVATION ENGINEERED IN GERMANY

HORN
GLASS INDUSTRIES

Electric Melting Technologies



Lecturer: **Dipl. Ing. Lars Biennek**
Head of Technology
HORN Glass Industries AG

Author: **Dipl. Ing. Lars Biennek**

Content

1. **Introduction into the all-electric melting process**
2. Existing container glass furnace for super flint 60 tpd
3. Modelling results super flint 140 tpd
4. Possibility of melting amber glass under cold-top condition
5. Economical comparison between an end-port fired furnace and an all-electric furnace
6. Future outlook
7. Conclusion

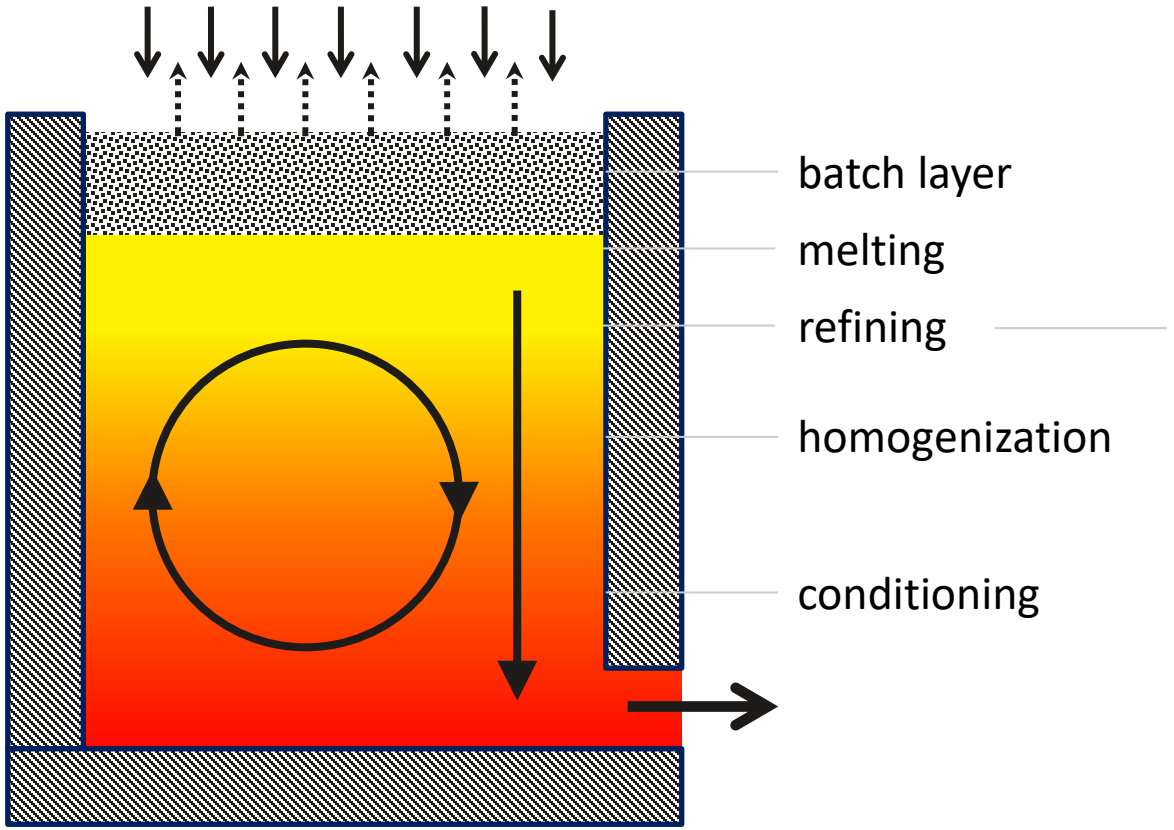
Basics of the all-electric melting process (cold top)

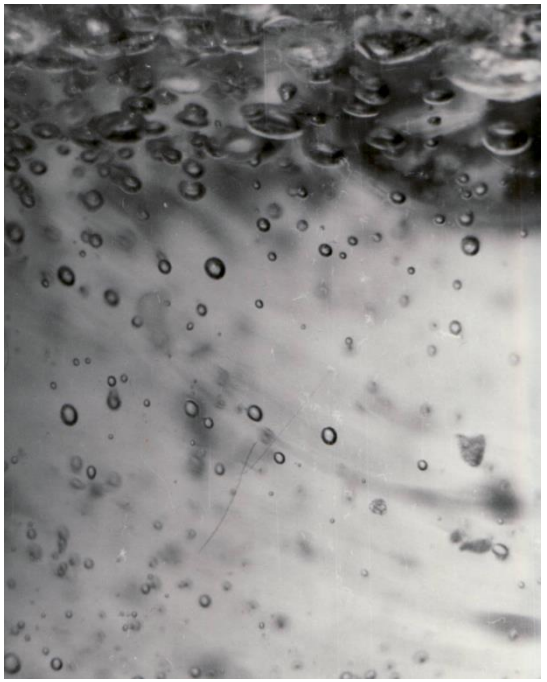
- Vertical melting process from the top down to the bottom (throat)
- Batch layer covers the entire glass bath and works as an thermal insulator
- The batch layer needs to bear a certain permeability for the gases from the batch decomposition
- Refining agents such as sulphur, chlorine, fluorine are recycled in the batch layer

Batch layer

- Most important prerequisite is a uniform and stable batch layer
  - Stability = f (melting rate)
  - Stability = f (raw materials, refining agents)
  - Stability = f (energy density distribution)
- Released gas from chemical reactions and rising bubbles have to penetrate the batch layer
- Cullet share of 30…60 % for minimum energy consumption depending on the glass

Cold-top melting process





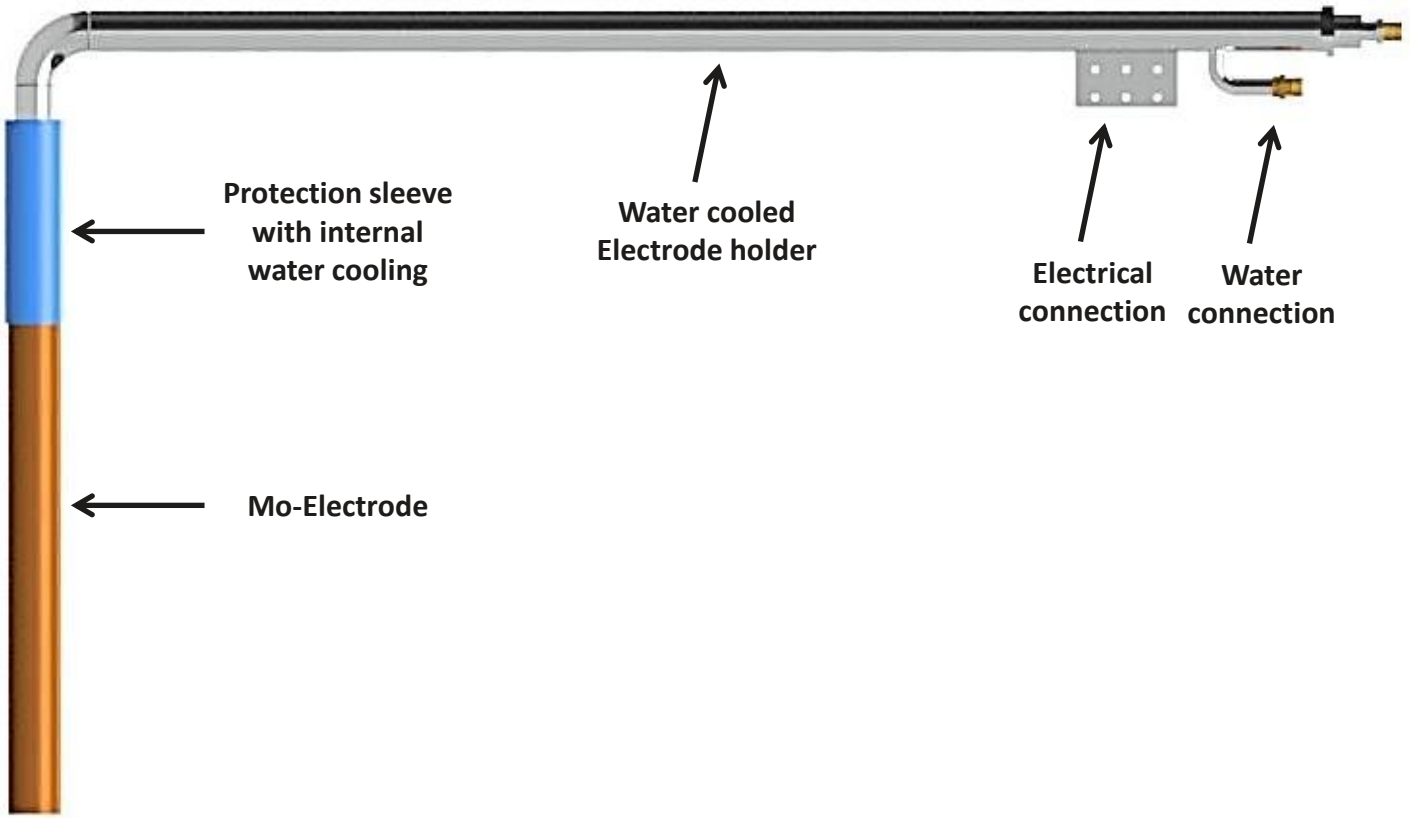
[1] Dr. Linz, Phd Electric melting of Glass

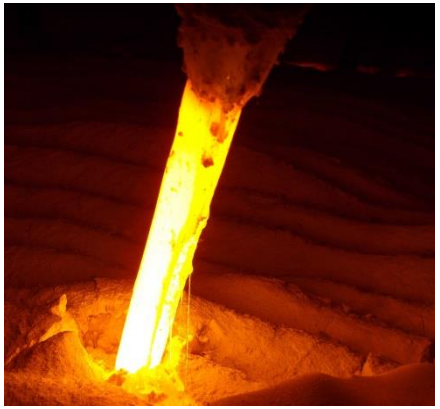
HORN GLASS INDUSTRIES

Temperature and energy fields

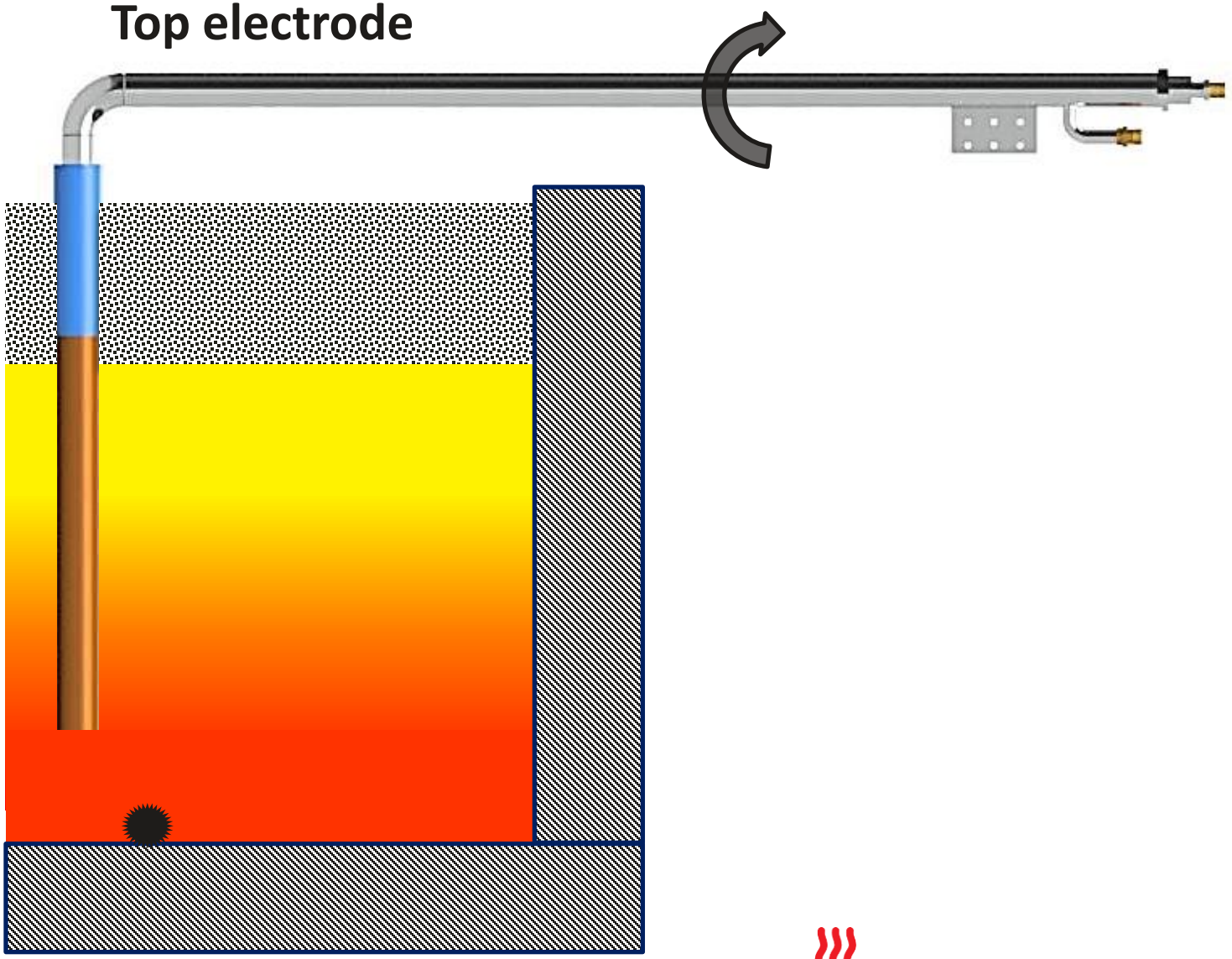
- Comparable high and homogeneous temperature level is giving reason for possible high specific melting rate
- Homogenous energy density fields under consideration of fixed convection by electrode position
  → too large distance between electrodes to be avoided!
- Large temperature and density gradient below the batch blanket is a must for stabilizing the first melting zone

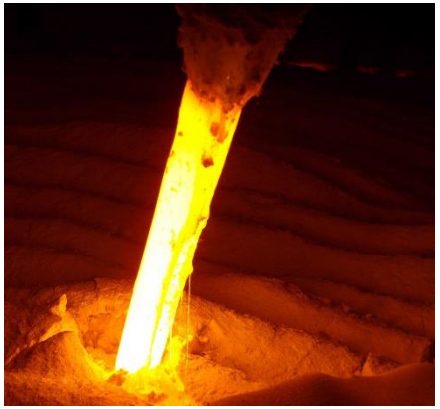
Top electrode



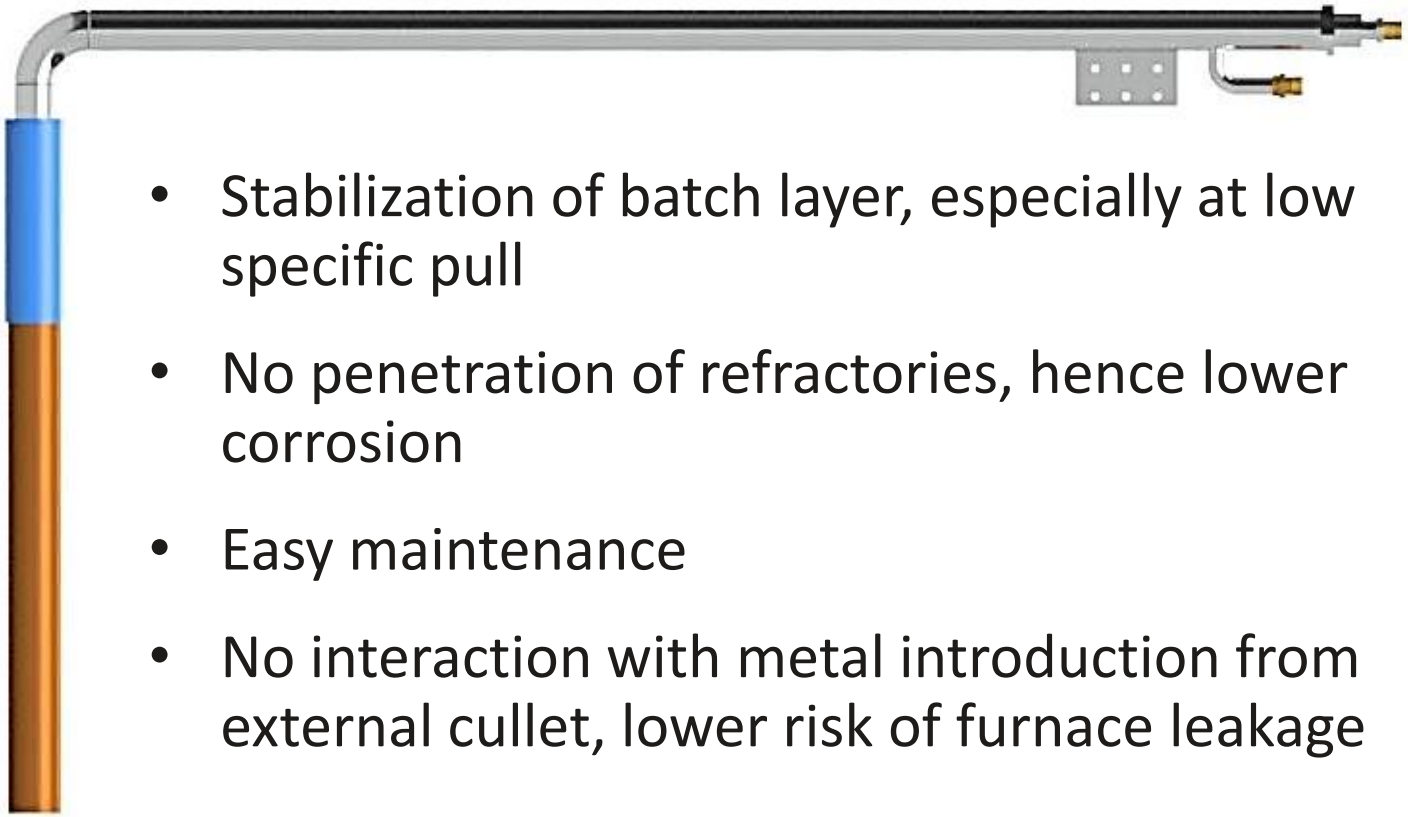


Top electrode

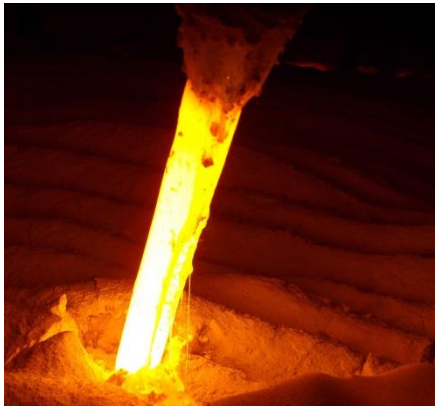




Top electrode



- Stabilization of batch layer, especially at low specific pull
- No penetration of refractories, hence lower corrosion
- Easy maintenance
- No interaction with metal introduction from external cullet, lower risk of furnace leakage



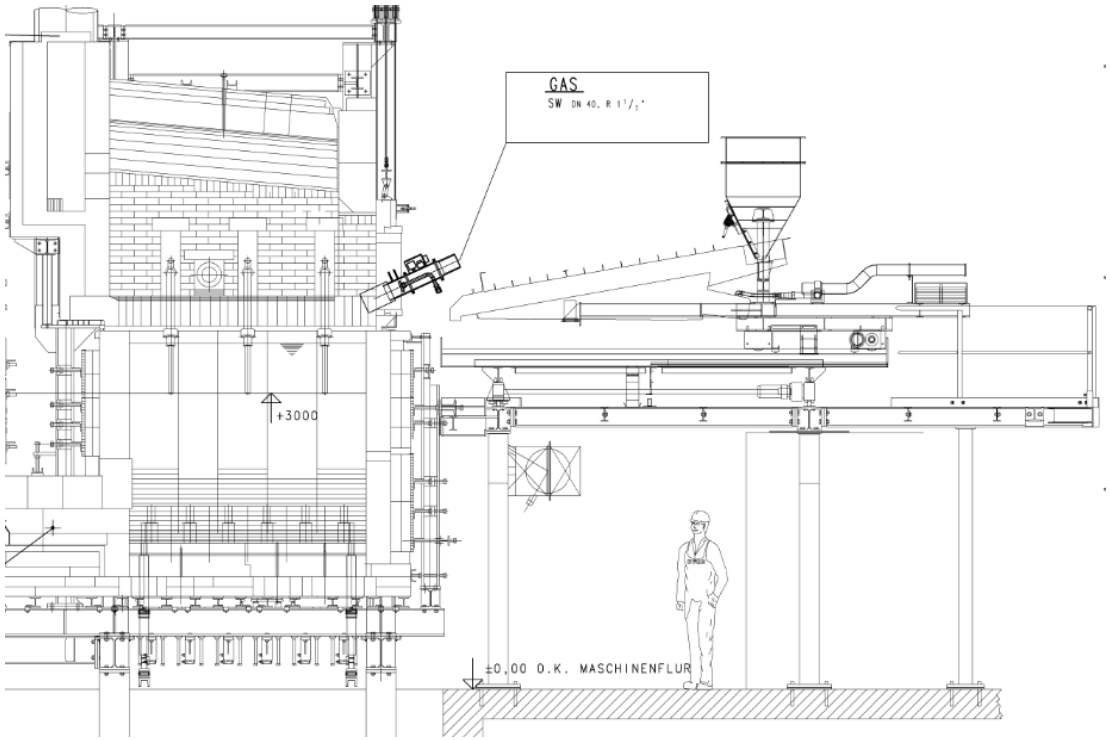
Advantages of all-electric melting

- lower investment cost
- Higher glass quality if proper designed
- less maintenance activities
- lower energy consumption
- Lowest CO_2 emission at plant site (batch-CO_2)
- Minimum air pollution, only bag filter necessary for dust emissions
- avoided problem with evaporation (knots, condensation of alkaline-borates in exhaust system)

Disadvantages of all-electric melting

- Shorter furnace campaign (50…70% lifetime compared to end-fired furnace)
- Less flexibility in daily pull changes (10% Steps)
- Less total flexibility in max/min pull (70…110%)
- Less cullet content possible (30…60%)

Introduction



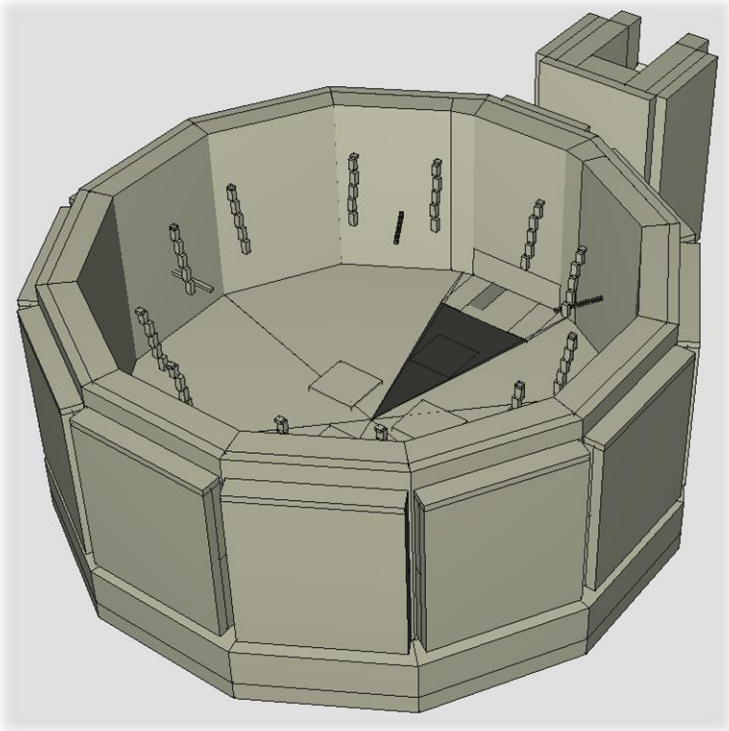
Something is wrong with the batch layer!?

After raw material adjustment it’s perfect!

Content

1. Introduction into the all-electric melting process
2. **Existing container glass furnace for super flint 60 tpd**
3. Modelling results super flint 140 tpd
4. Possibility of melting amber glass under cold-top condition
5. Economical comparison between an end-port fired furnace and an all-electric furnace
6. Future outlook
7. Conclusion

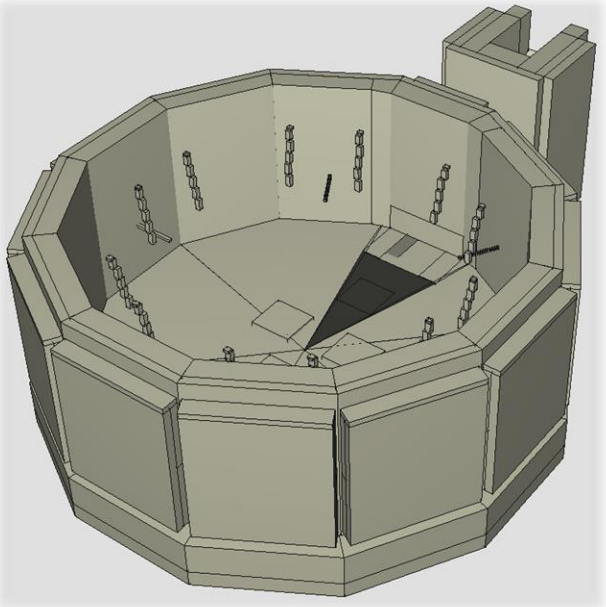
Existing all-electric furnace for super flint glass



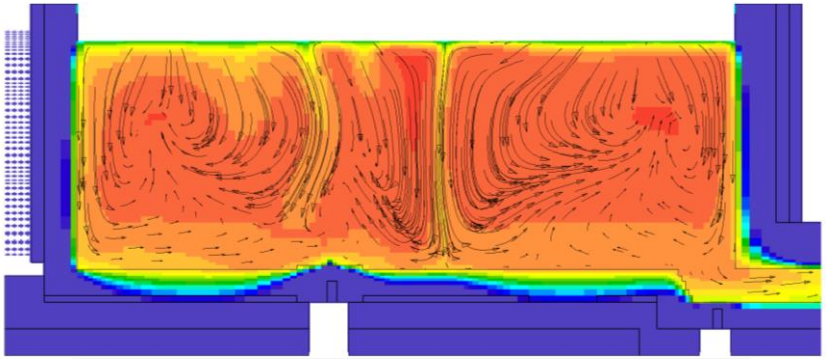
Existing all-electric furnace for super flint glass

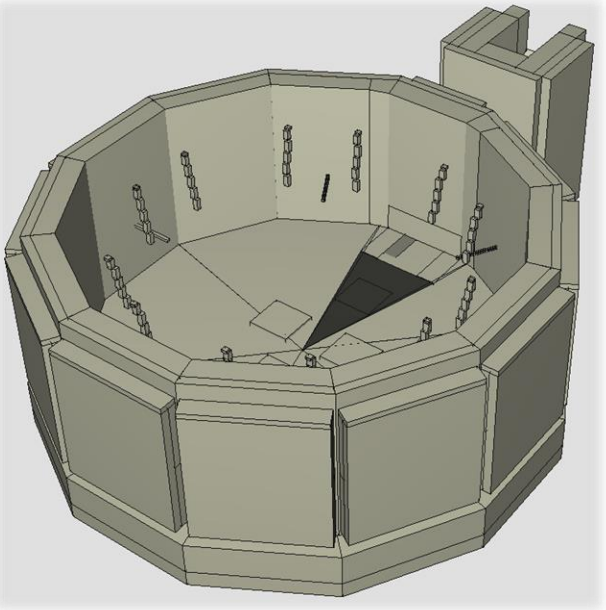
Main characteristics:

Type of glass	Super flint
Seeds 0.1-0.25 mm	< 10 pcs
Pull	57 t/d
Melting surface	20 m2
Dimension	5 m
Specific melting rate	2.85 t/m2d
Depth of tank	1,9 m
Cullet content	38 %
Total power	2,570 kW
Specific energy consumption	1.05 kWh/kg
Upper temperature	1523°C
Exit temperature	1511°C
Furnace campaign	5 years



Basic modelling results:





- High convection flow, constant high temp level in the whole furnace
- Depth of 1900 mm and high temperature level – excellent glass quality
- Min. Residence time 12 min (excluded batch layer)

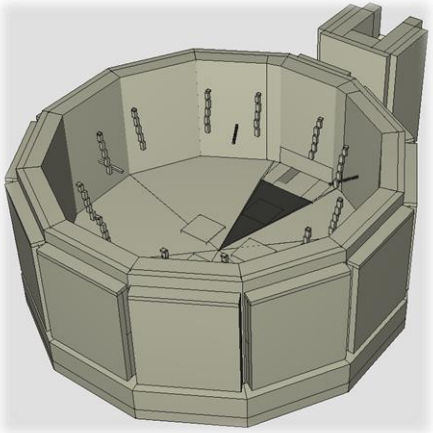
Content

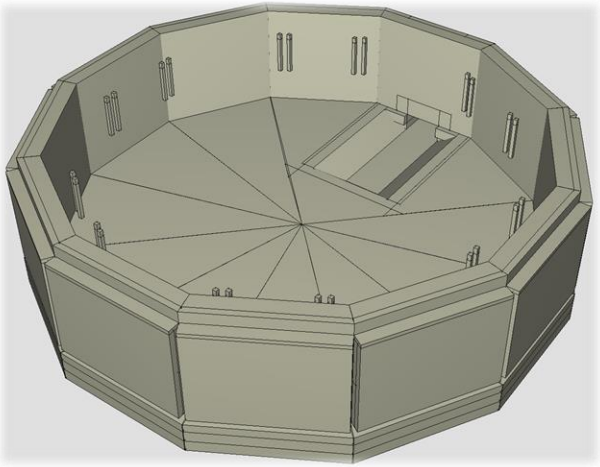
1. Introduction into the all-electric melting process
2. Existing container glass furnace for super flint 60 tpd
3. **Modelling results super flint 140 tpd**
4. Possibility of melting amber glass under cold-top condition
5. Economical comparison between an end-port fired furnace and an all-electric furnace
6. Future outlook
7. Conclusion

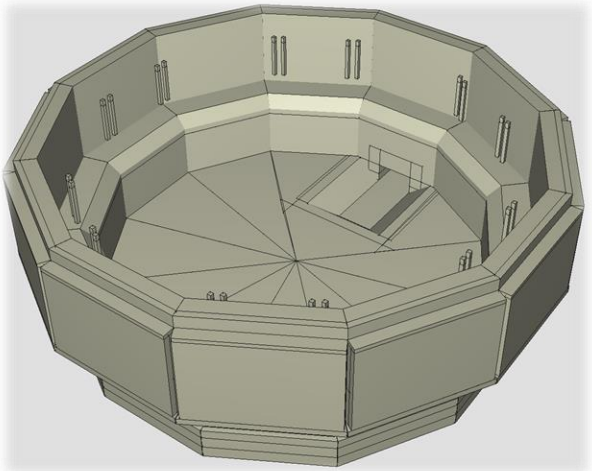
Main characteristics:

Type of furnace	Round	Round	Round with shelf
Pull	58 t/d	140 t/d	140 t/d
Melting surface	20 m2	50 m2	50 m2
Dimension	5 m	7.9 m	7.9 m
Depth of tank	1,9 m	1.9	2.55
Total power	2,570 kW	5,875 kW	6,055
Specifc energy consumption	1.05 kWh/kg	1.0 kWh/kg	1.04 kWh/kg
Upper temperature	1523°C	1522 °C	1501 °C
Exit temperature	1511°C	1507 °C	1493 °C

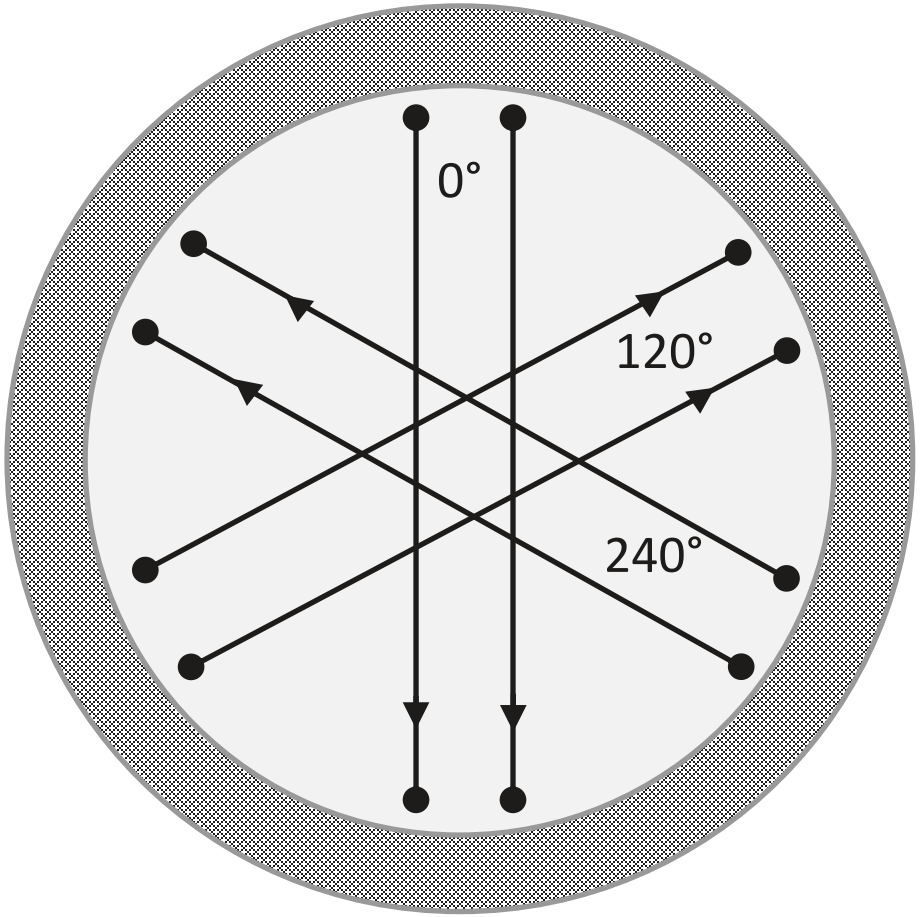
Main characteristics:



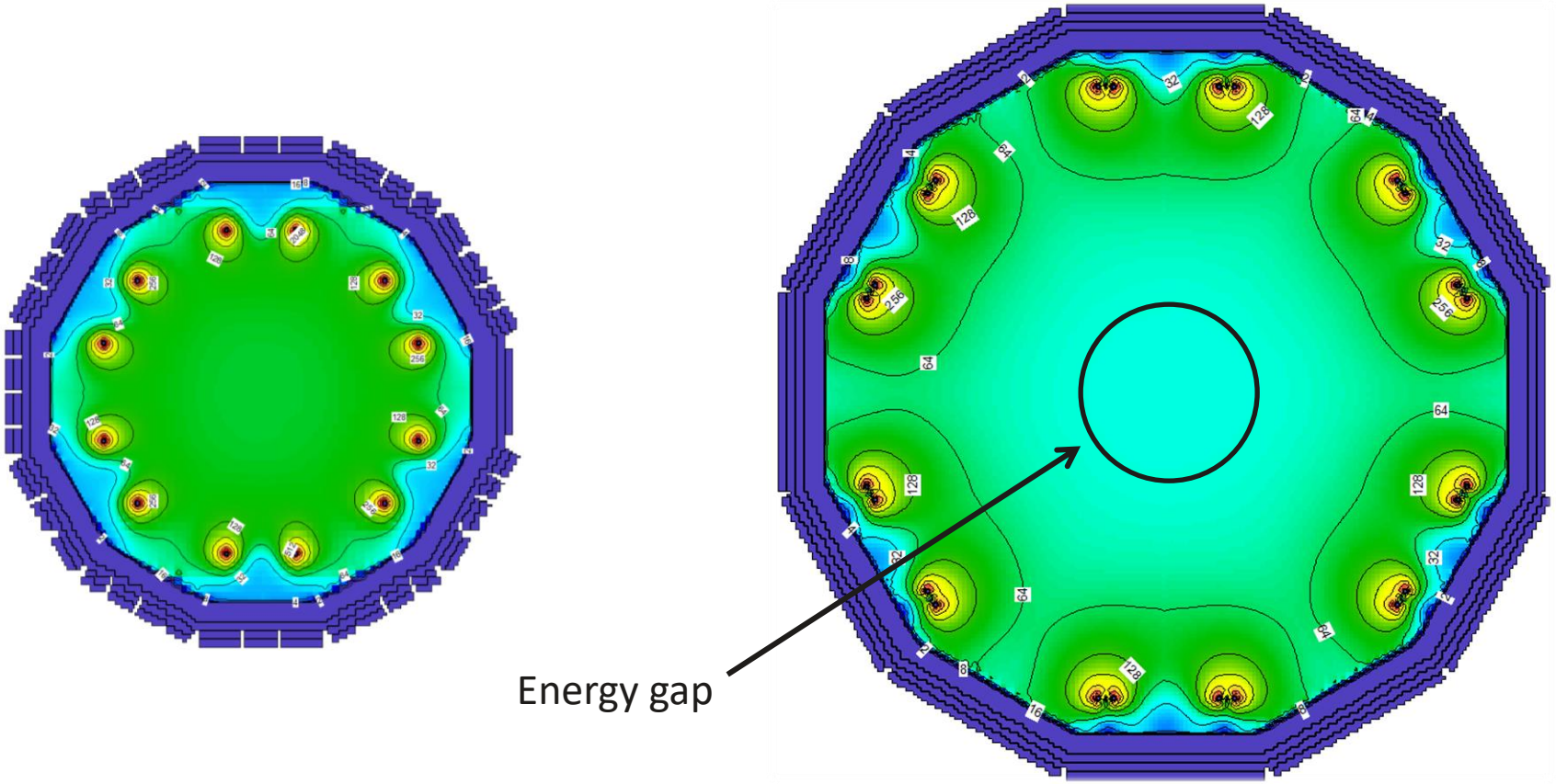




Electrical connection – 3 Phase 120°:

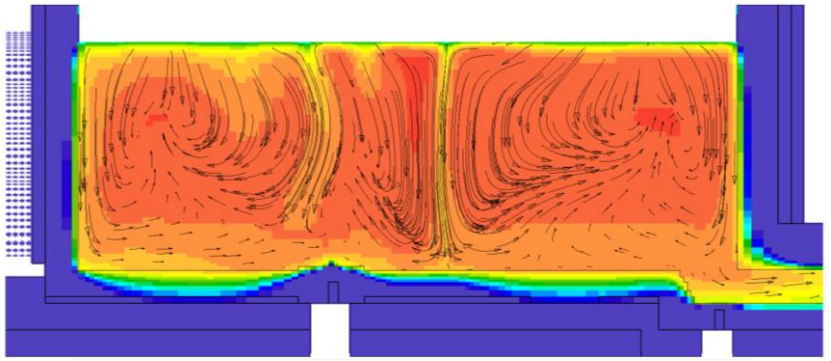


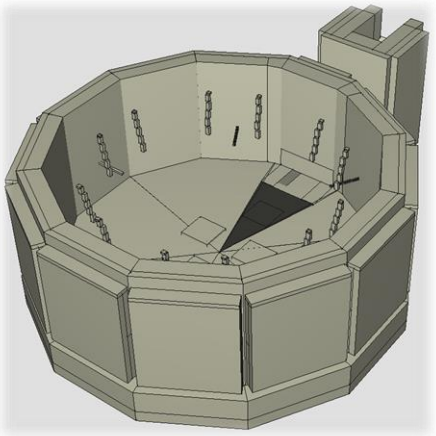
Electrical connection – 3 Phase 120°:



Basic modelling results:

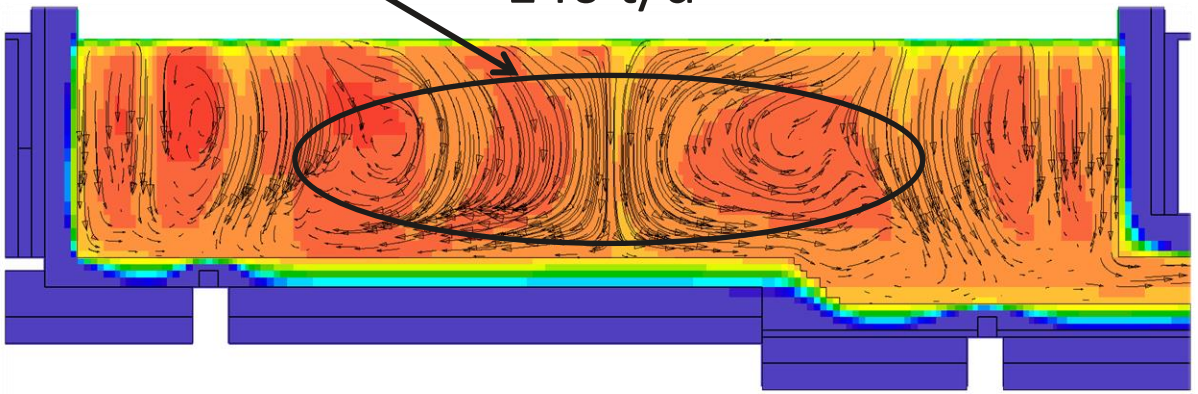
60 t/d

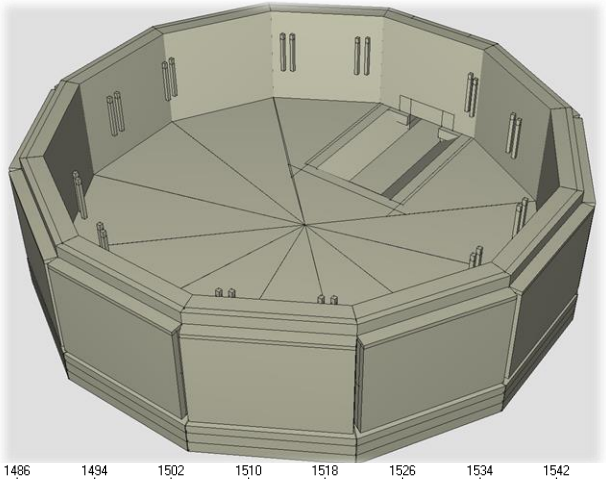




Instable convection pattern

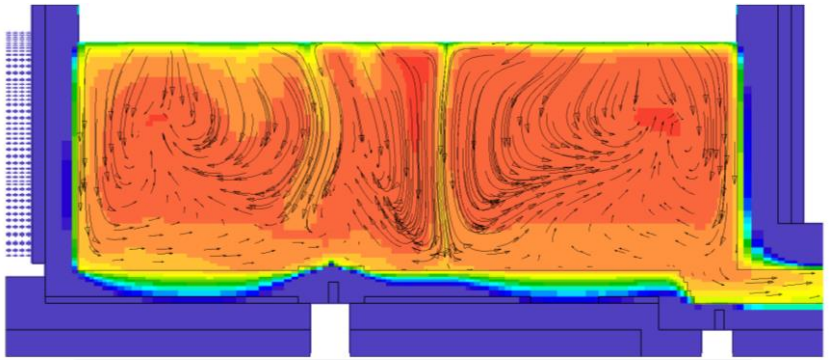
140 t/d

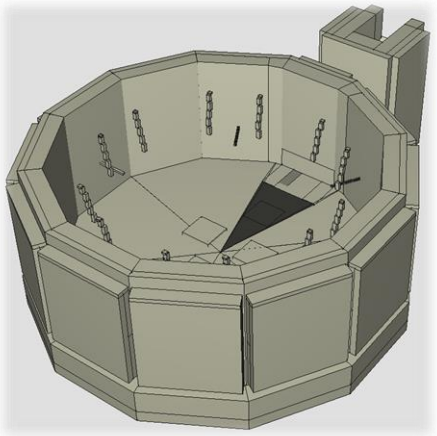




Basic modelling results:

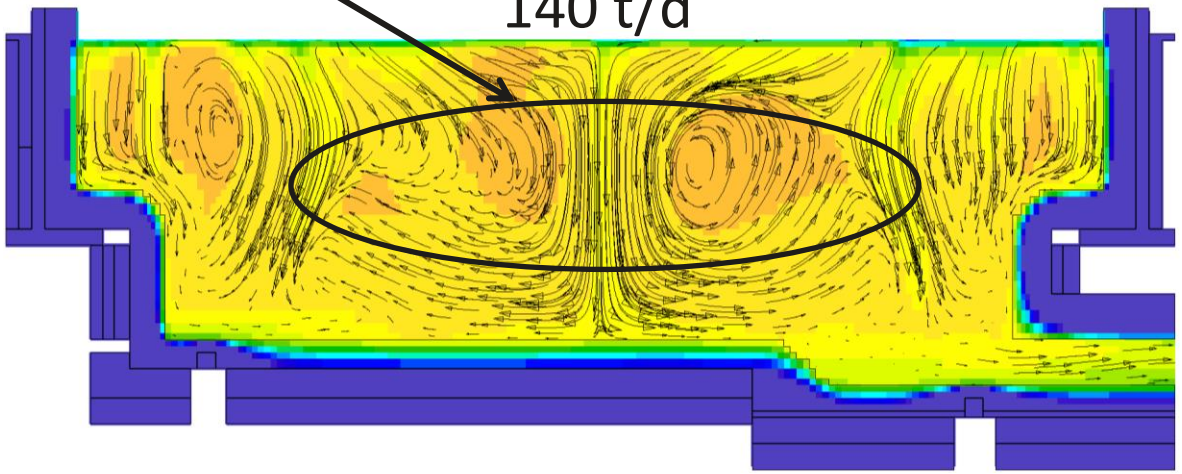
60 t/d

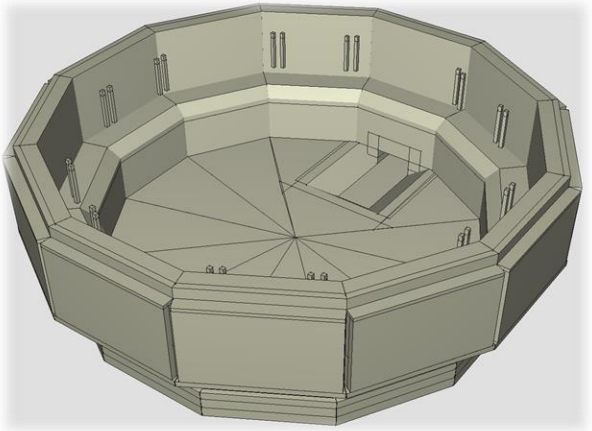


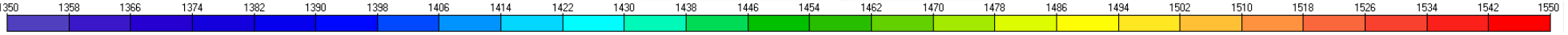


Shelf stabilises convection pattern but not sufficiently

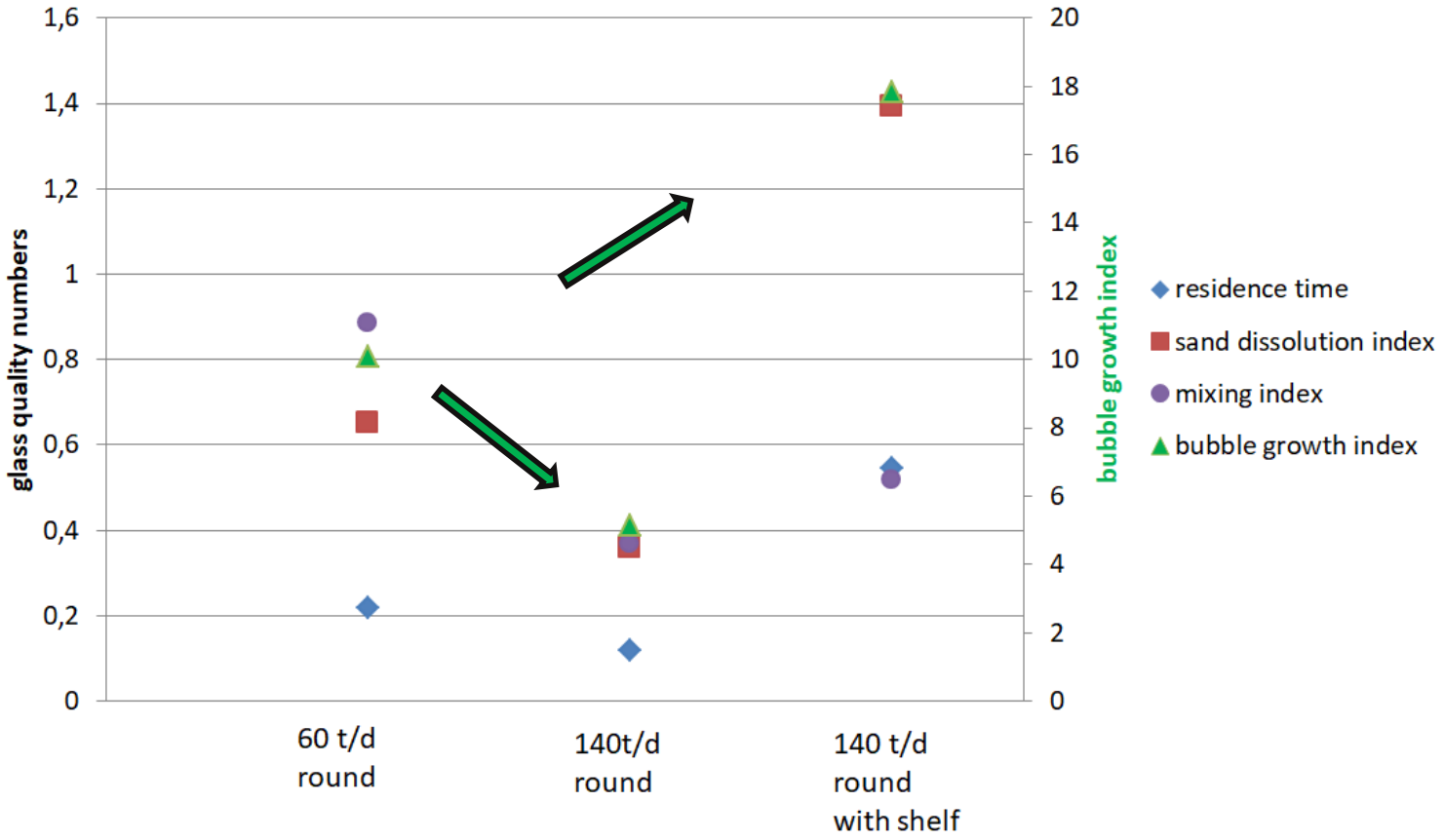
140 t/d







Basic modelling results:

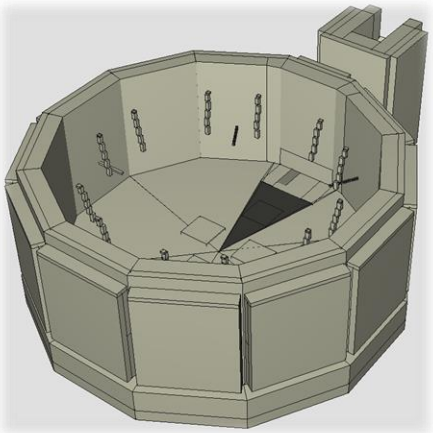


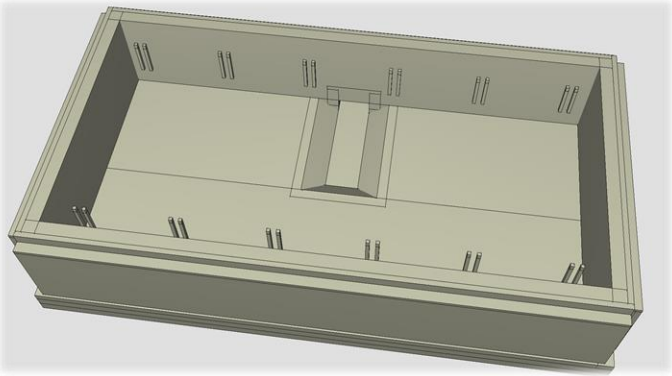
Scale-up of a round furnace significantly decreases the demanded glass quality!!!

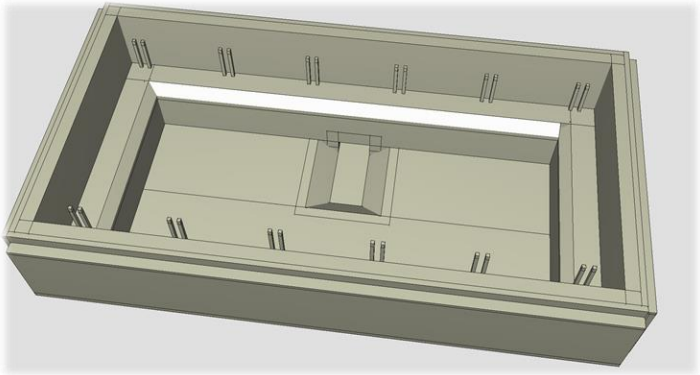
Main characteristics:

Type of furnace	Round	Rectangular	Rectangular with shelf
Pull	58 t/d	140 t/d	140 t/d
Melting surface	20 m2	50 m2	50 m2
Dimension	5 m	5 x 10 m	5 x 10 m
Depth of tank	1.9 m	1.9	2.55
Total power	2,570 kW	5,955 kW	6,060 kW
Specific energy consumption	1.05 kWh/kg	1.02 kWh/kg	1.04 kWh/kg
Upper temperature	1523°C	1522 °C	1502 °C
Exit temperature	1511°C	1507 °C	1470 °C

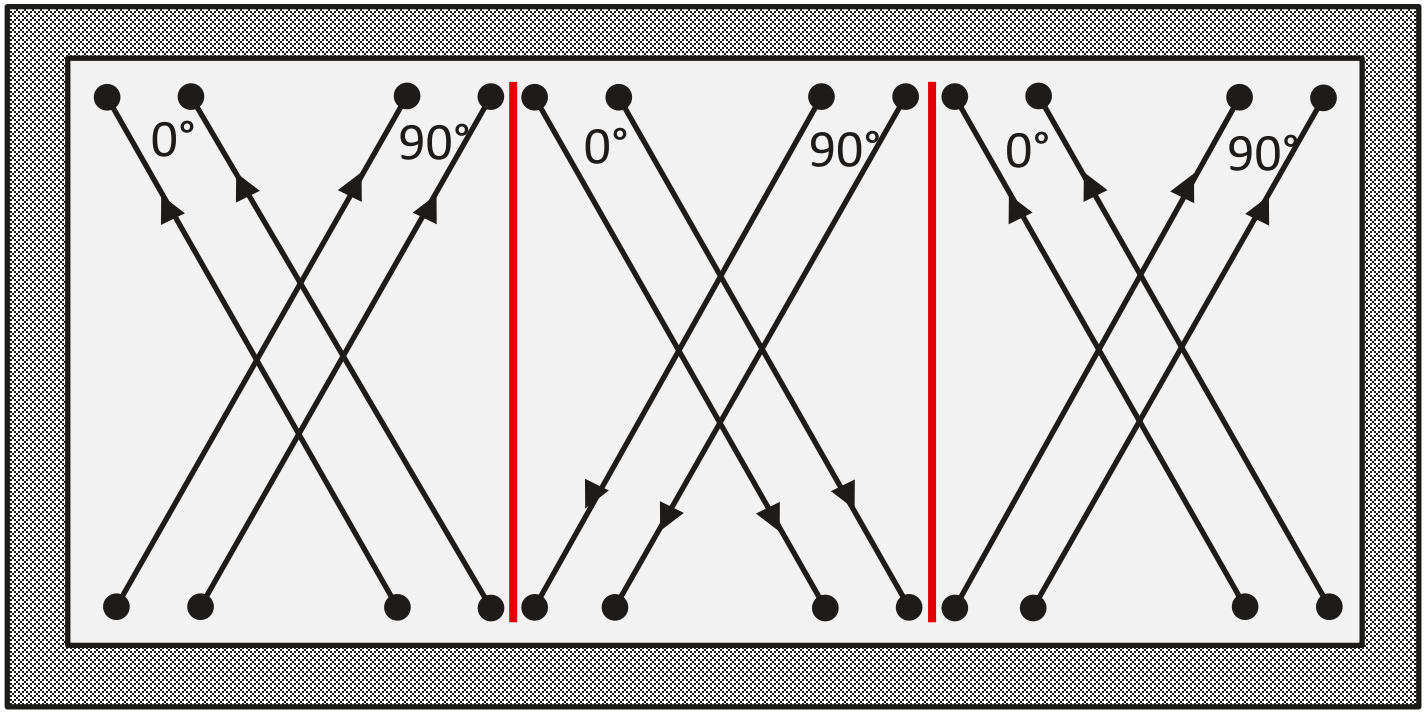
Main characteristics NEU:



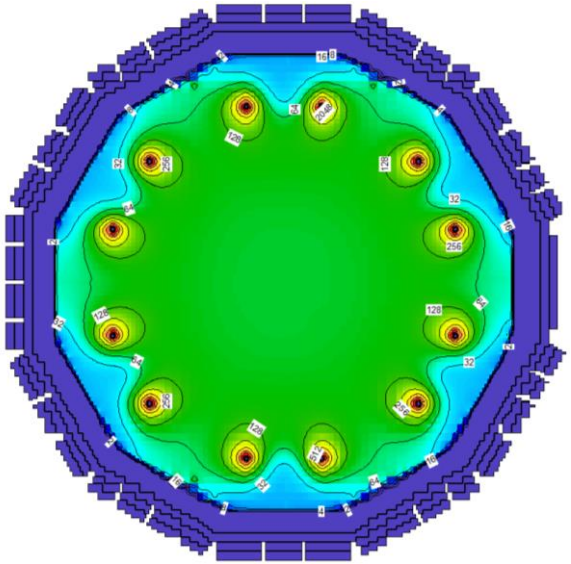


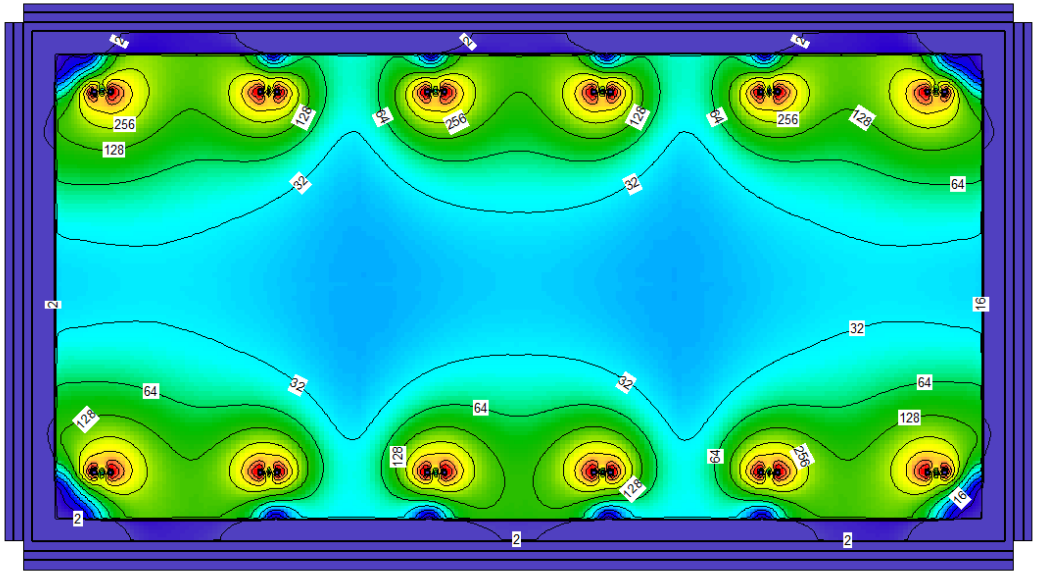


Electrical connection – 3 Phase → 2 Phase (SCOTT) 90°:



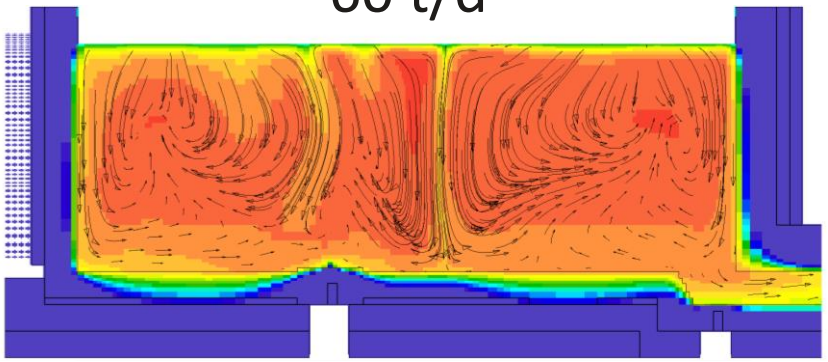
Electrical connection – 3 Phase → 2 Phase (SCOTT) 90°:



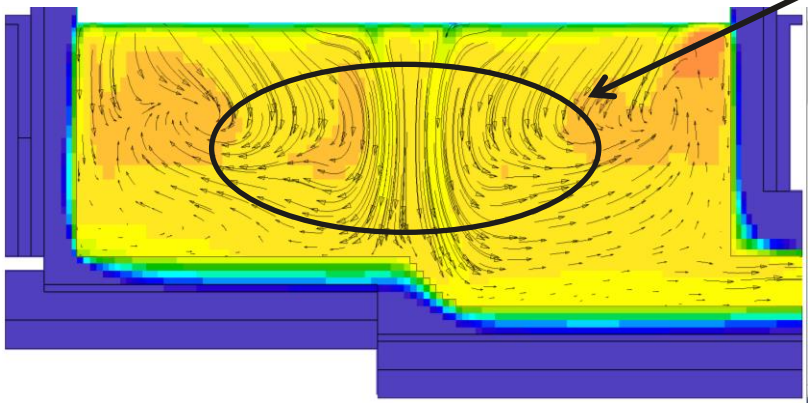


Basic modelling results:

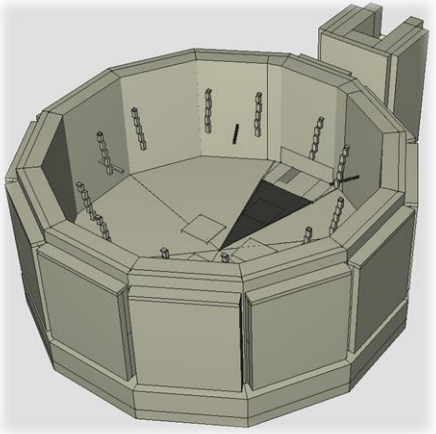
60 t/d

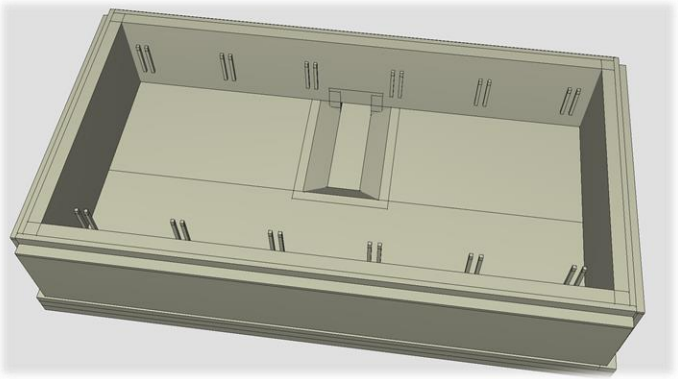


140 t/d

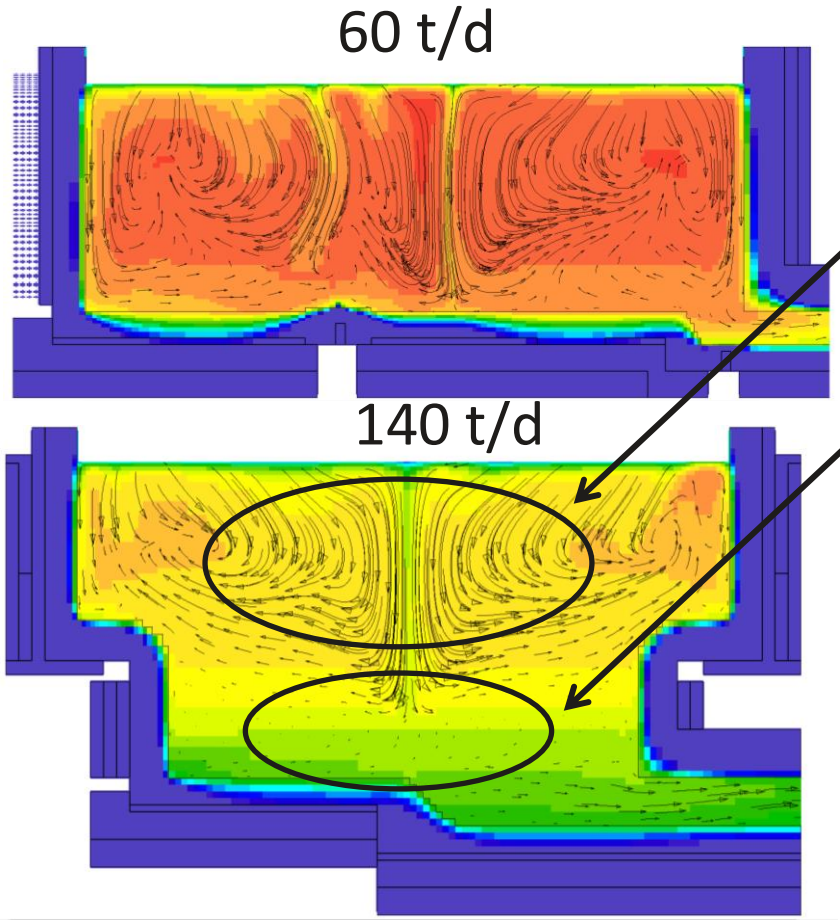


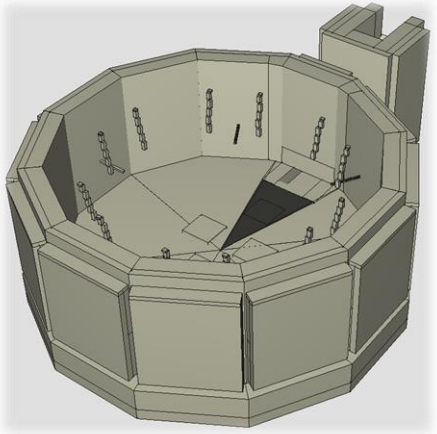
Convection defined

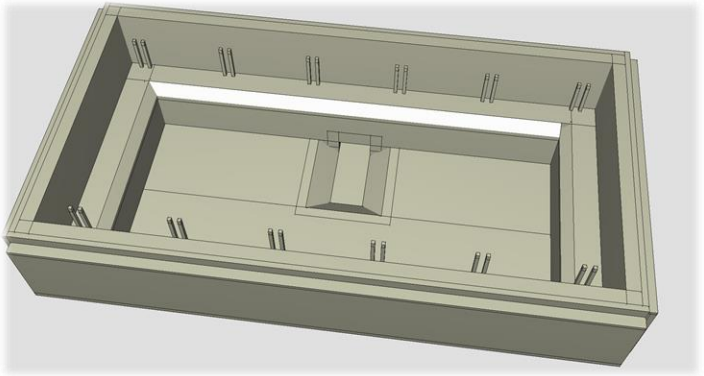




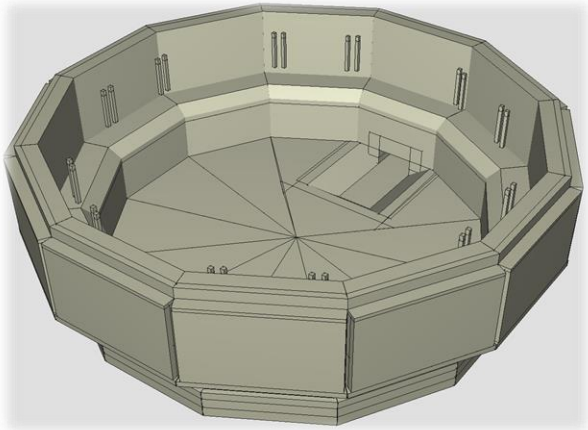
Basic modelling results:

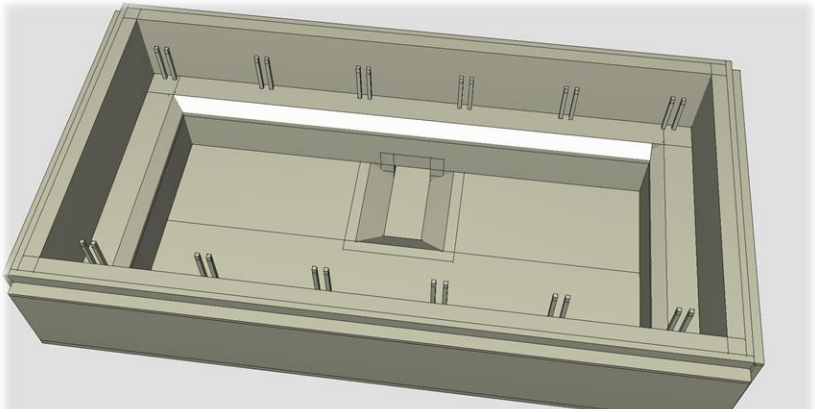


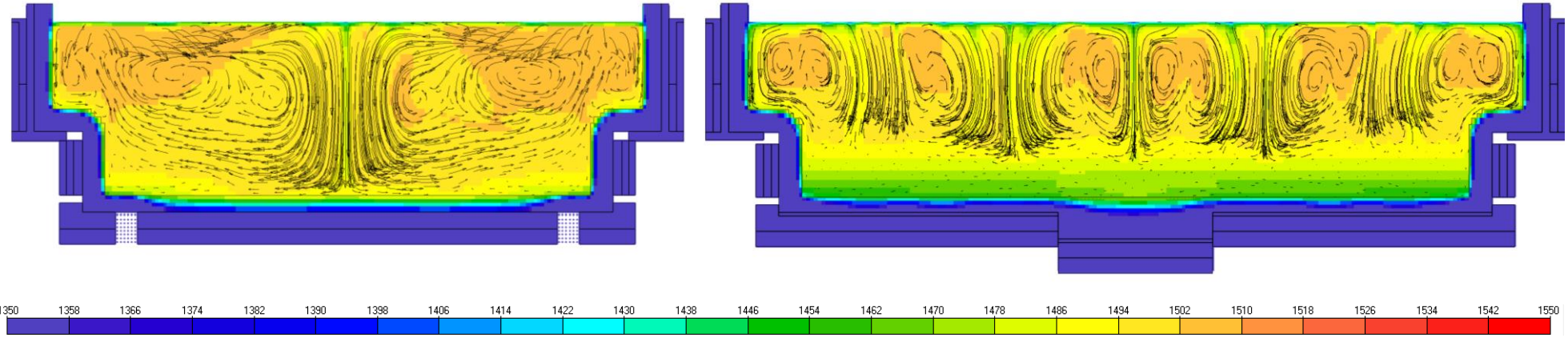




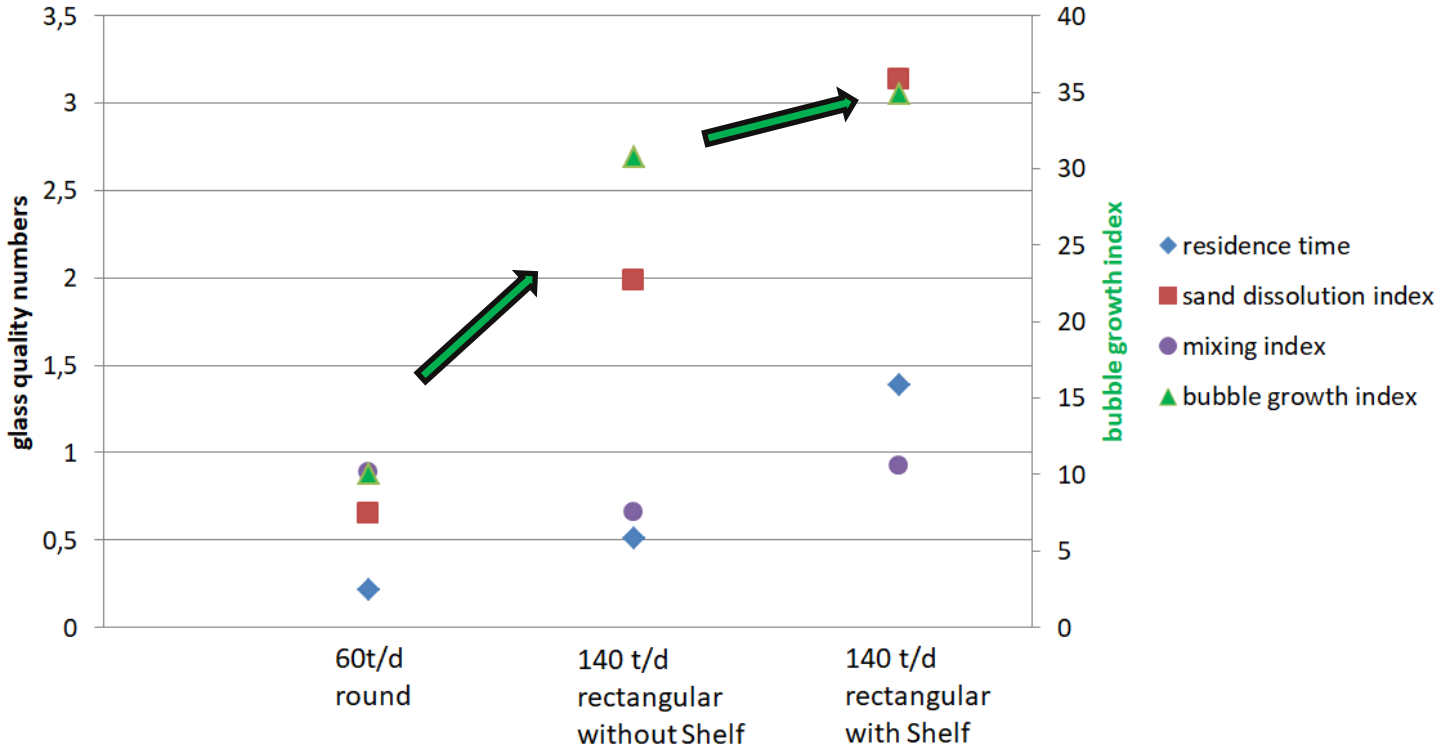
Basic modelling results:





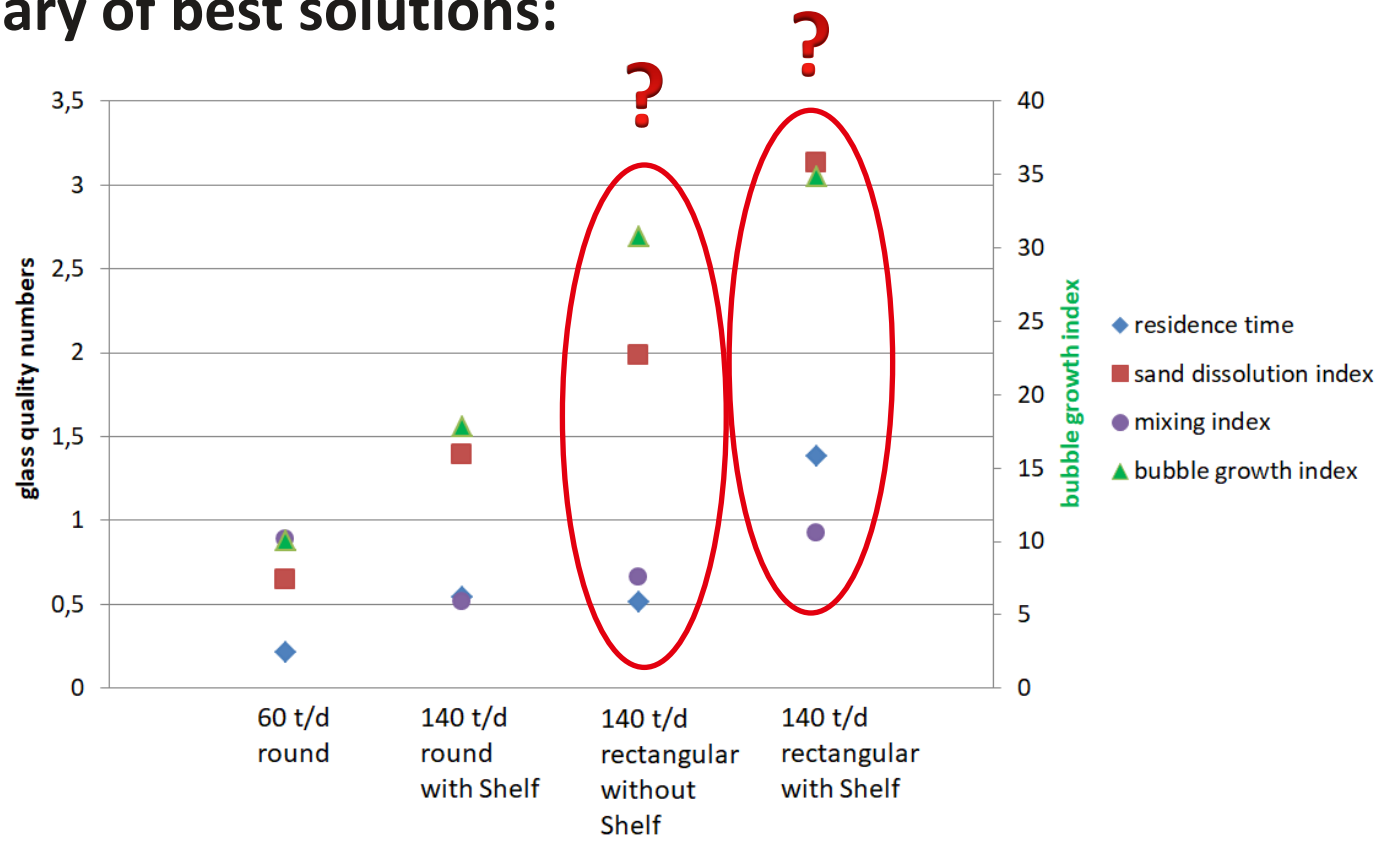


Basic modelling results:



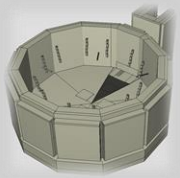
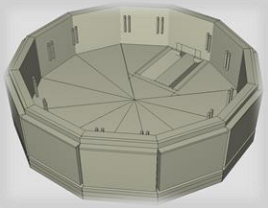
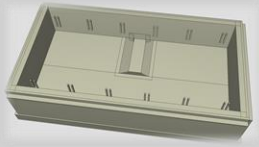
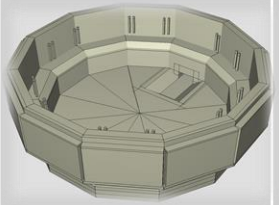
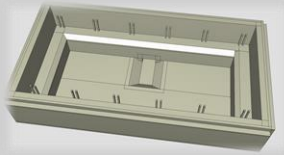
Scale-up by means of an rectangular furnace significantly increases the demanded glass quality!!!

Summary of best solutions:

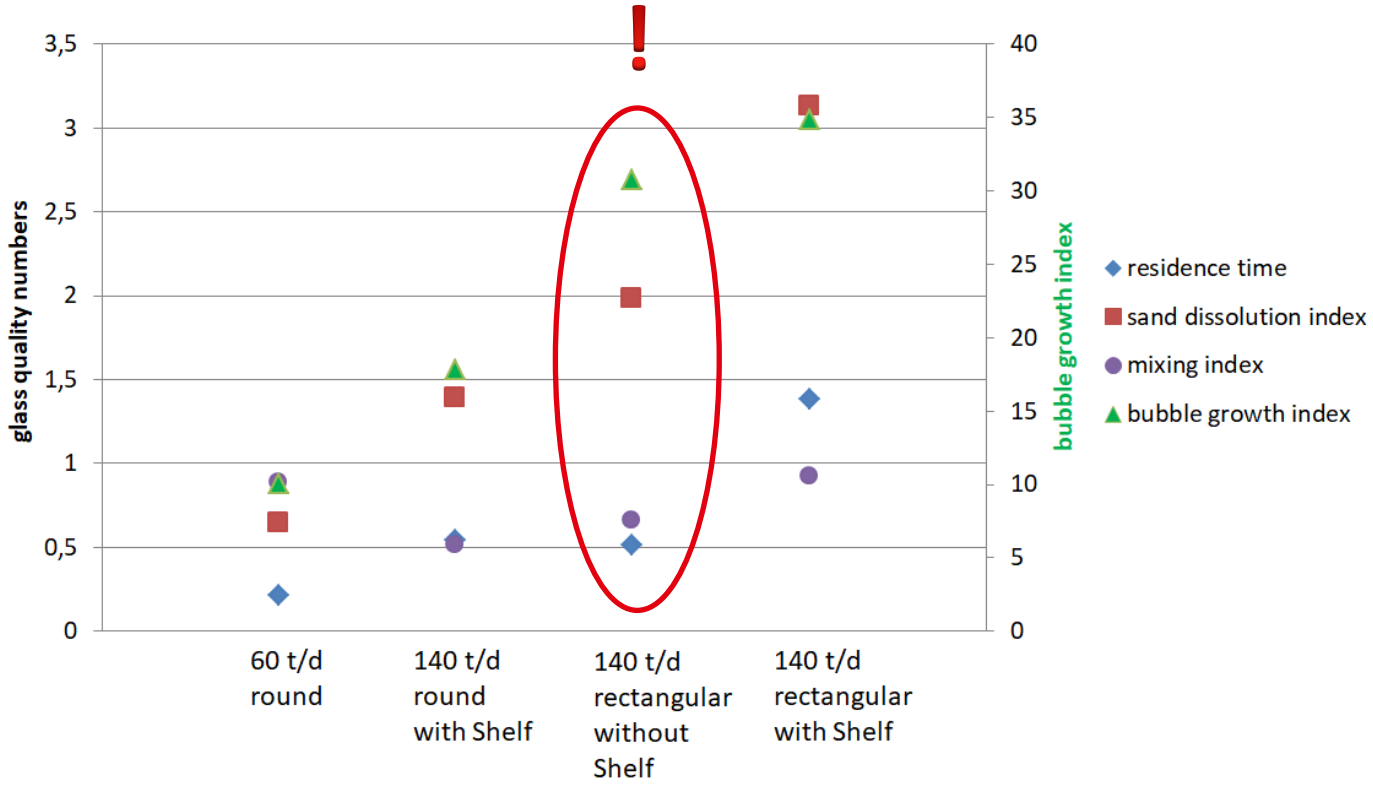


An rectangular furnace is the reasonable version to ensure the demanded glass quality !!! With shelf or without shelf?

Summary of best solutions:

					
Residence time	0,22h	0,12h	0,51h	0,54h	1,39h
Sand dissolution index	0,7	0,4	2,0	1,4	3,1
Bubble grow index	10,1	5,2	30,8	17,8	34,9
Maintenance	++	++	++	-	-
Complexity	++	++	++	-	-

Summary of best solutions:

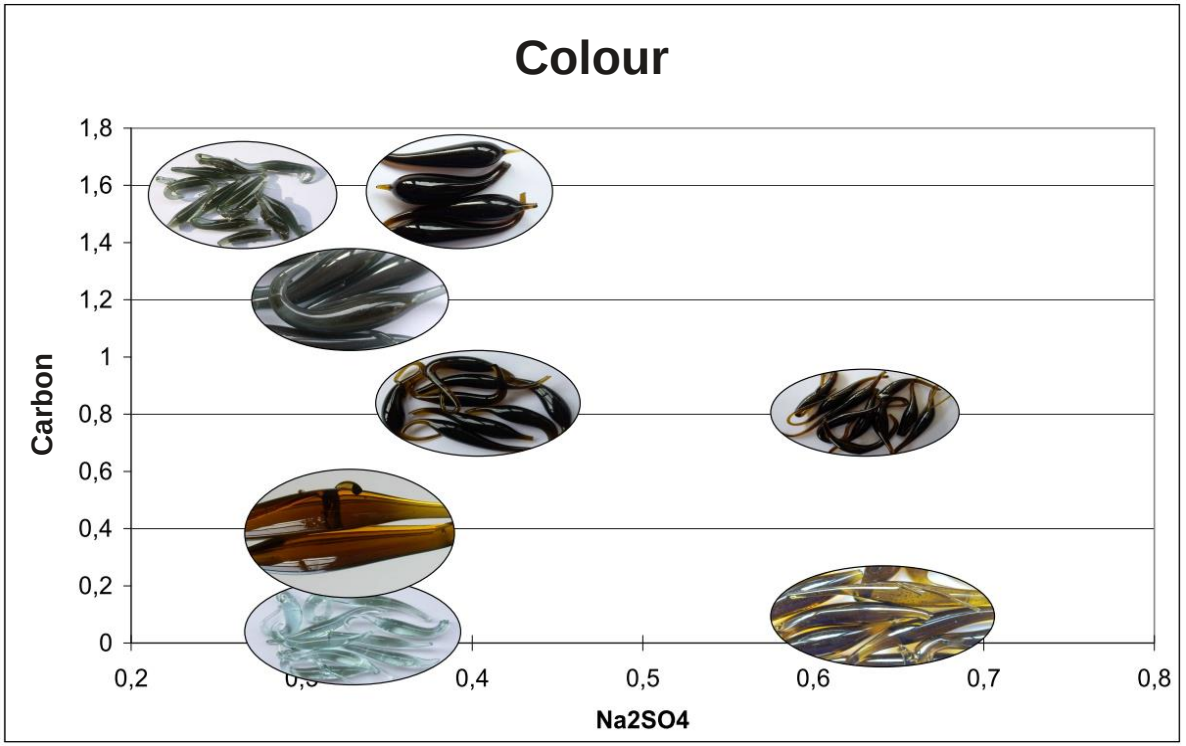


An rectangular furnace WIHTOUT SHELF is the reasonable version for good glass quality, simple maintenance!!! c

Content

1. Introduction into the all-electric melting process
2. Existing container glass furnace for super flint 60 tpd
3. Modelling results super flint 140 tpd
4. **Possibility of melting amber glass under cold-top condition**
5. Economical comparison between an end-port fired furnace and an all-electric furnace
6. Future outlook
7. Conclusion

Adjustment of amber under cold-top conditions:

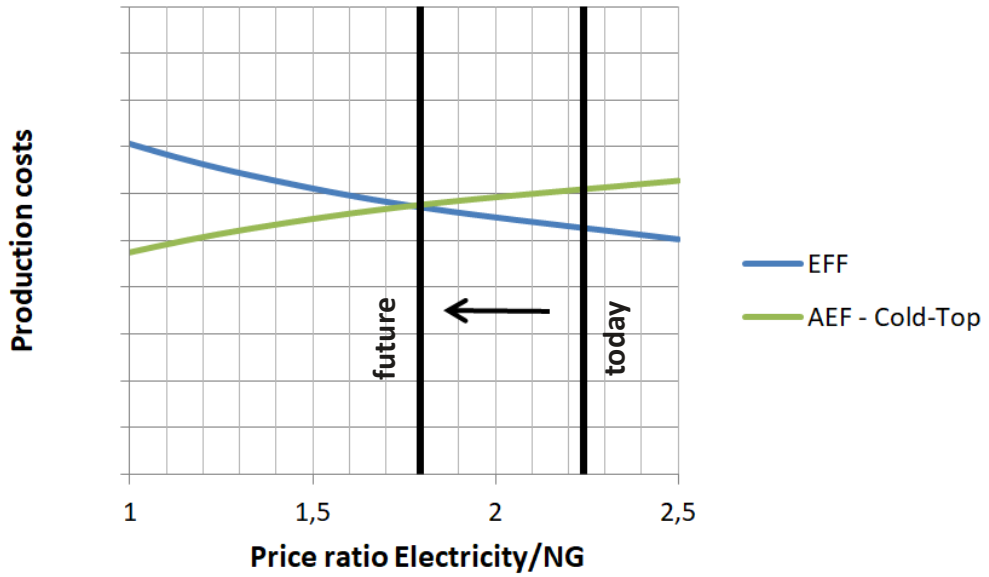


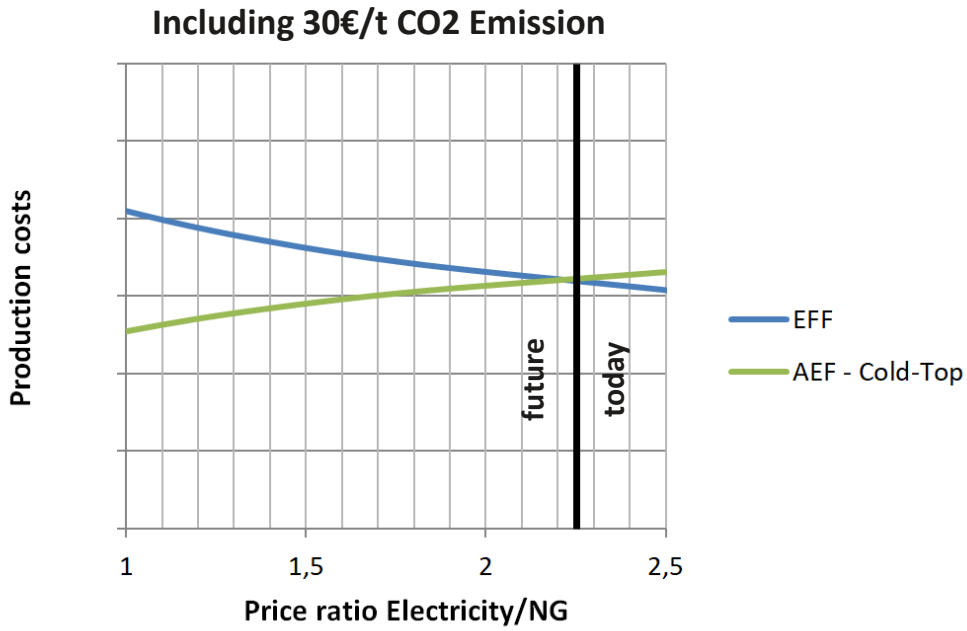
Amber colour can be easily adjusted under cold top conditions whereby the amount of carbon an Na_2SO_4 differs from hot top conditions

Content

1. Introduction into the all-electric melting process
2. Existing container glass furnace for super flint 60 tpd
3. Modelling results super flint 140 tpd
4. Possibility of melting amber glass under cold-top condition
5. **Economical comparison between an end-port fired furnace and an all-electric furnace**
6. Future outlook
7. Conclusion

Economical comparison





Content

1. Introduction into the all-electric melting process
2. Existing container glass furnace for super flint 60 tpd
3. Modelling results super flint 140 tpd
4. Possibility of melting amber glass under cold-top condition
5. Economical comparison between an end-port fired furnace and an all-electric furnace
6. **Future outlook**
7. Conclusion

1. All-electric furnace with a capacity of 300 tpd

- Rectangular base as perfect basis for scale-up
- Dimensions of melting surface 16.5m x 6.5m
- 4-5 electrode heating modules

2. Two all-electric furnace with a capacity of 150 tpd

- No need for scale-up
- One joint distributor
- Mixing of the two melts at the entrance of the forehearths

3. Modelling of amber and green glass

Content

1. Introduction into the all-electric melting process
2. Existing container glass furnace for super flint 60 tpd
3. Modelling results super flint 140 tpd
4. Possibility of melting amber glass under cold-top condition
5. Economical comparison between an end-port fired furnace and an all-electric furnace
6. Future outlook
7. **Conclusion**

Conclusion

Is the electric power a possible solution for green glass melting process?

What about the energy suppliers?

Are they ready to supply reliable CO_2-free electricity for an reasonable price?

THANK YOU FOR YOUR ATTENTION!

HORN GLASS INDUSTRIES

innovation ENGINEERED IN GERMANY