TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG
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INSTITUT FÜR KERAMIK, GLAS- UND BAUSTOFFTECHNIK

Fuel economics and effect of glass pull by change of batch mix

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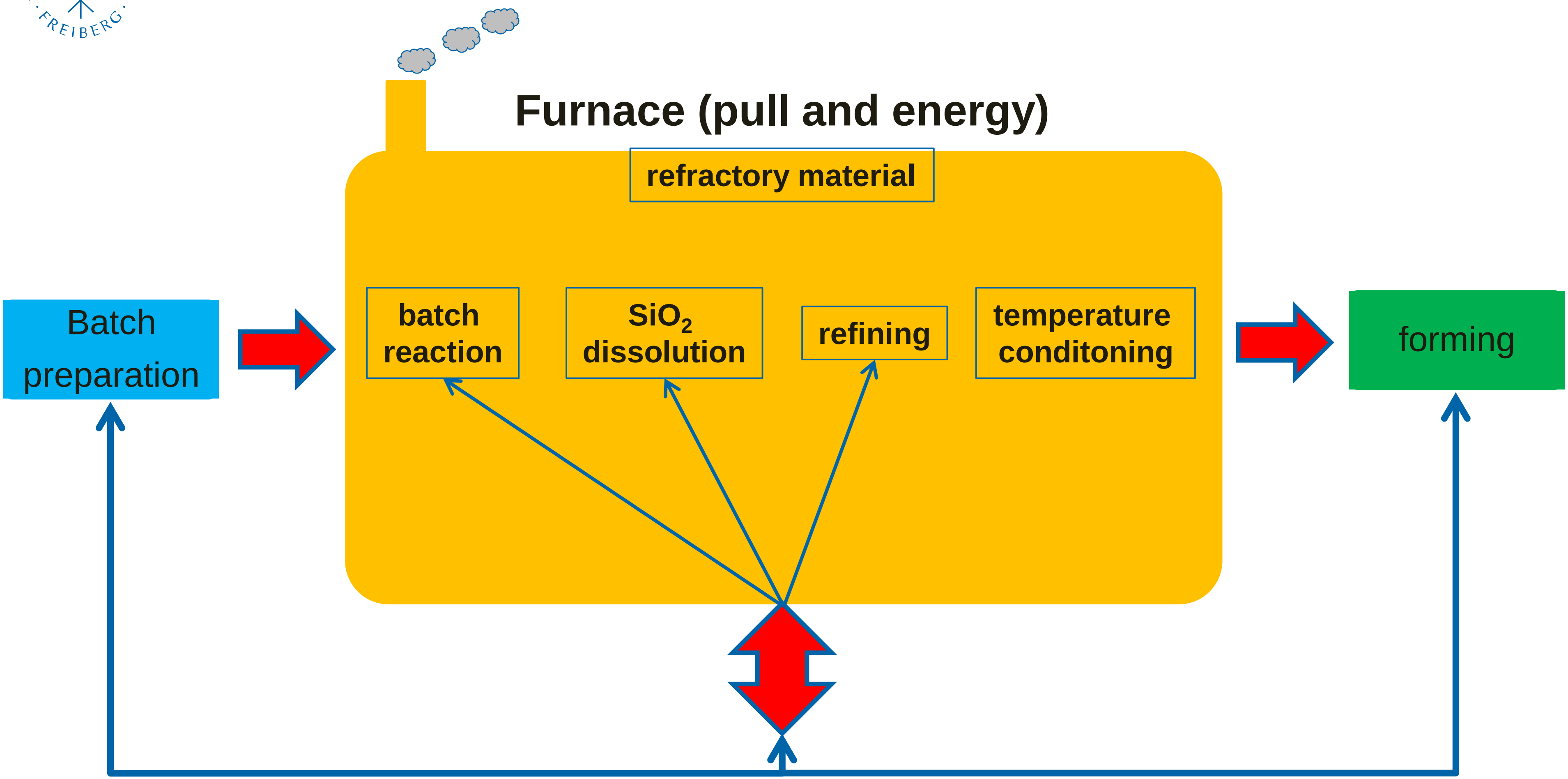
Glass production: Interconnected Mulit-Parameter-Process



- compactification
- huminity
- demixing
- grain size distribution and morphology
- batch + cullet preheating

- CaO content
- hydroxidic raw material
- length of glass - workability

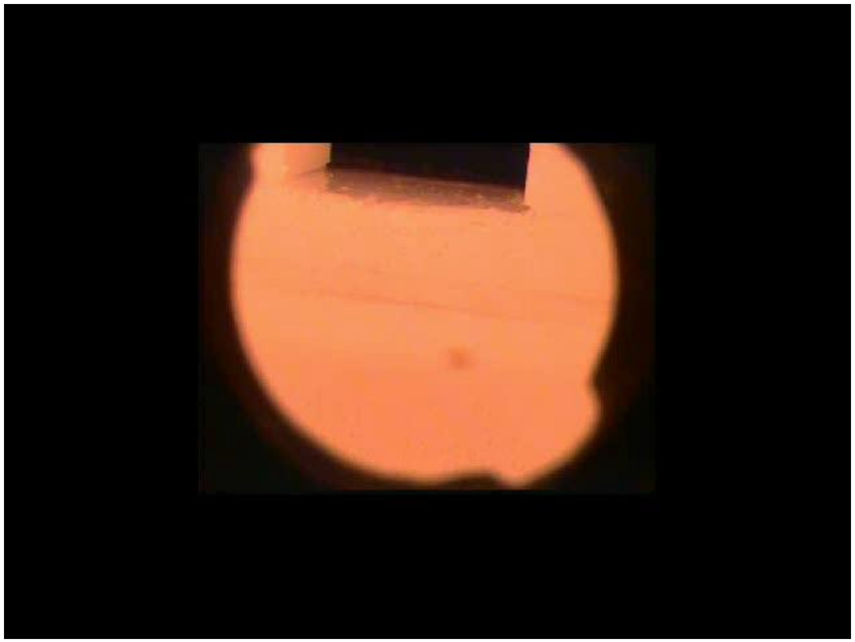
Batch compactification:

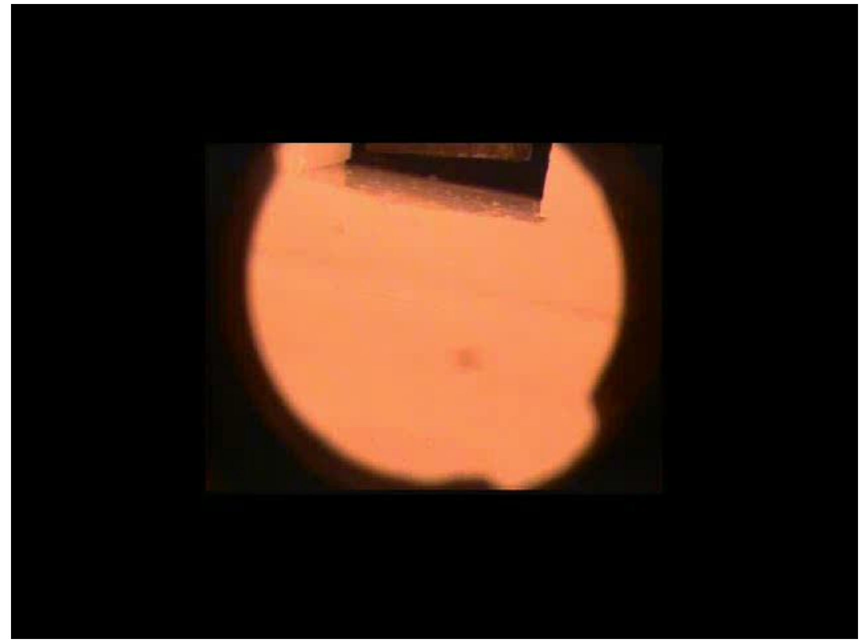
Advantages:

Better heat transfer,
Use of fine coarse raw material and cullet (light soda, dolomite) without risk of carry over: Incresed life time and long lasting efficiency of the regenerator
Strong acceleration of all furnace processes: less energy use, pull rate increase
Improved possibilities for batch preheating
No batch sticking in silos
Low amount of water, huminity for batch preparation
No demixing of batch material
Reduced evaporation especially of alkaline, boron

Disadvantages:

Cost of fine grinding of raw material and binder
Cost of compactivication





Hydroxidic raw material : $Ca(OH)_2$, same glass composition

Advantages:

Acceleratet batch reaction (changed partial pressure)

Improved radiation interaction (icreased OH concentration), higher temperature gradient, improved flow patterns

Improved fining process

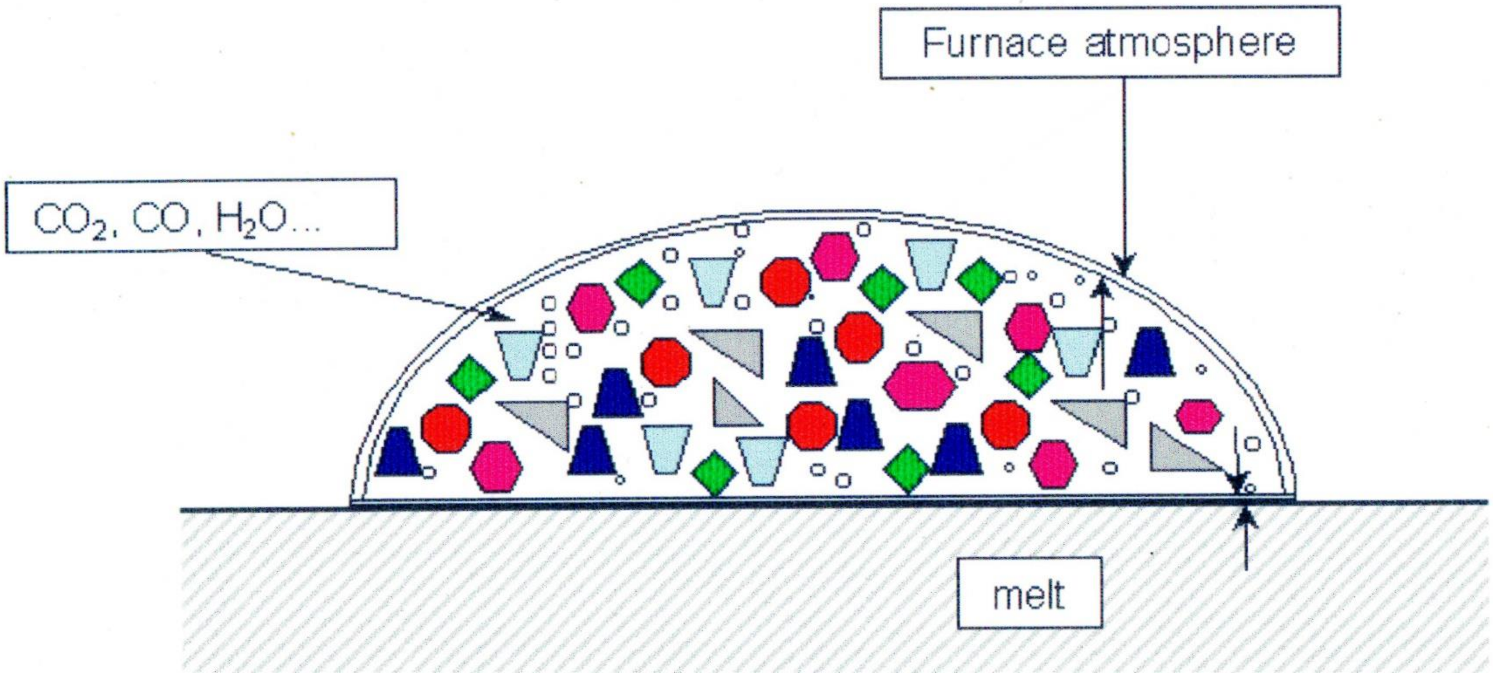
Disadvantage:

Slightly increased batch cost by 20/80 hydroxid/carbonatic material

Changed operation of the furnace

Result: less energy consumption and strong increased pull rate

Special gas conditions in the batch blanket



Partial pressure discussion:

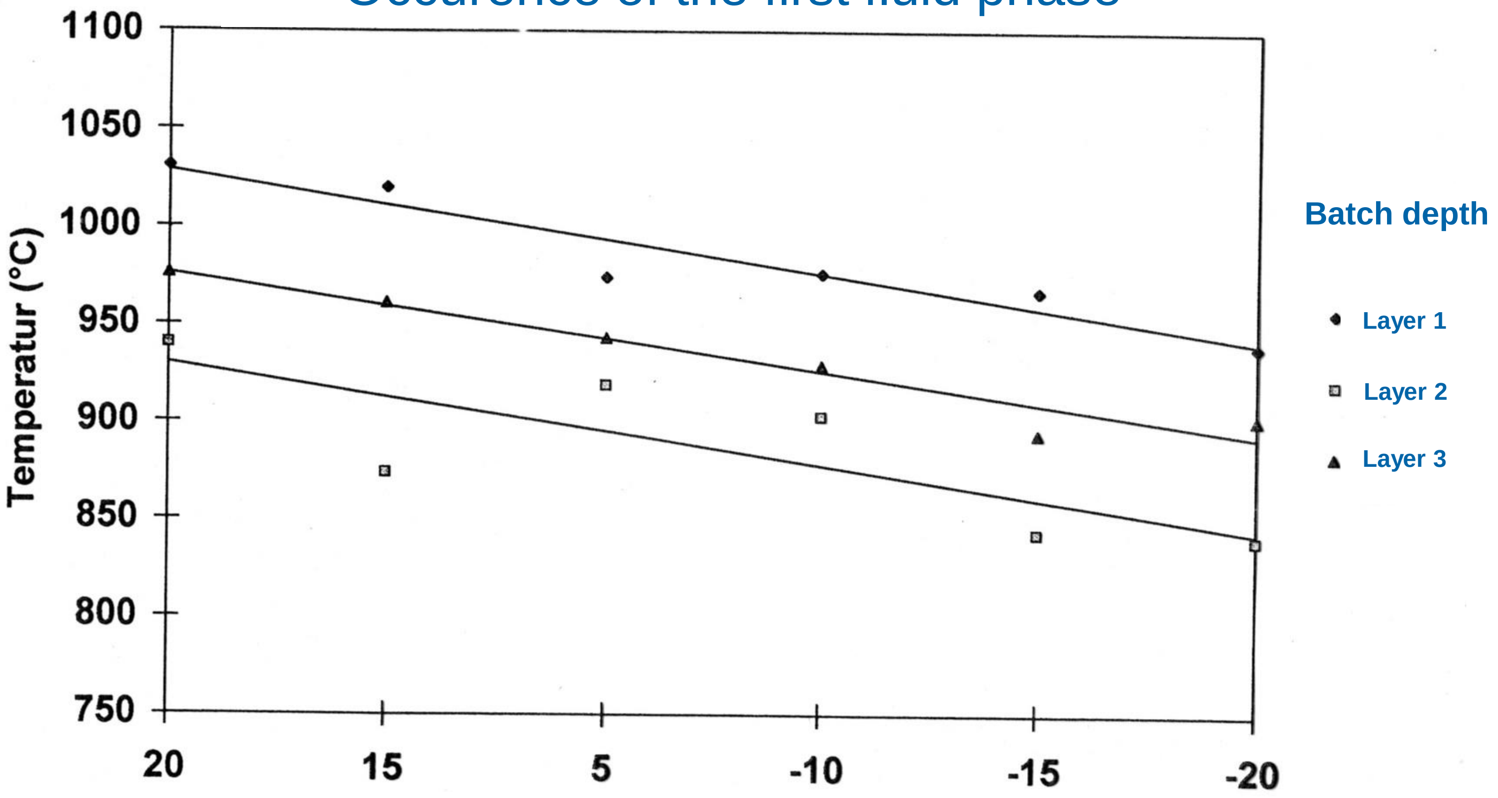
For example:

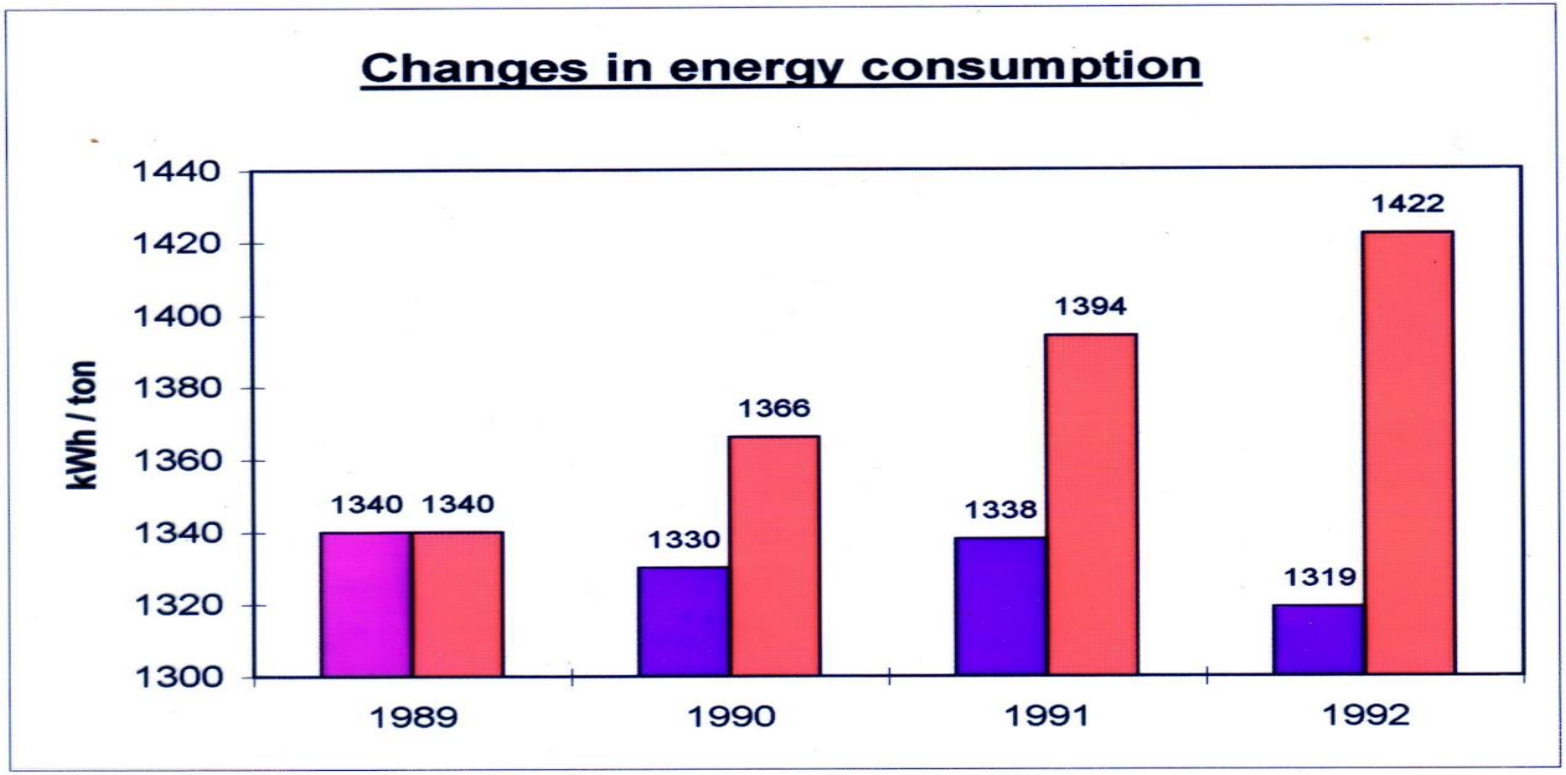
$CaCO_3$ ➔ $CaO + CO_2$ (p_{CO_2} =1 bar) 910°C

$Na_2Ca(CO_3)_2$ ➔ $CaO+Na_2O + 2\ CO_2$ (p_{CO_2}=1 bar) 960 °C

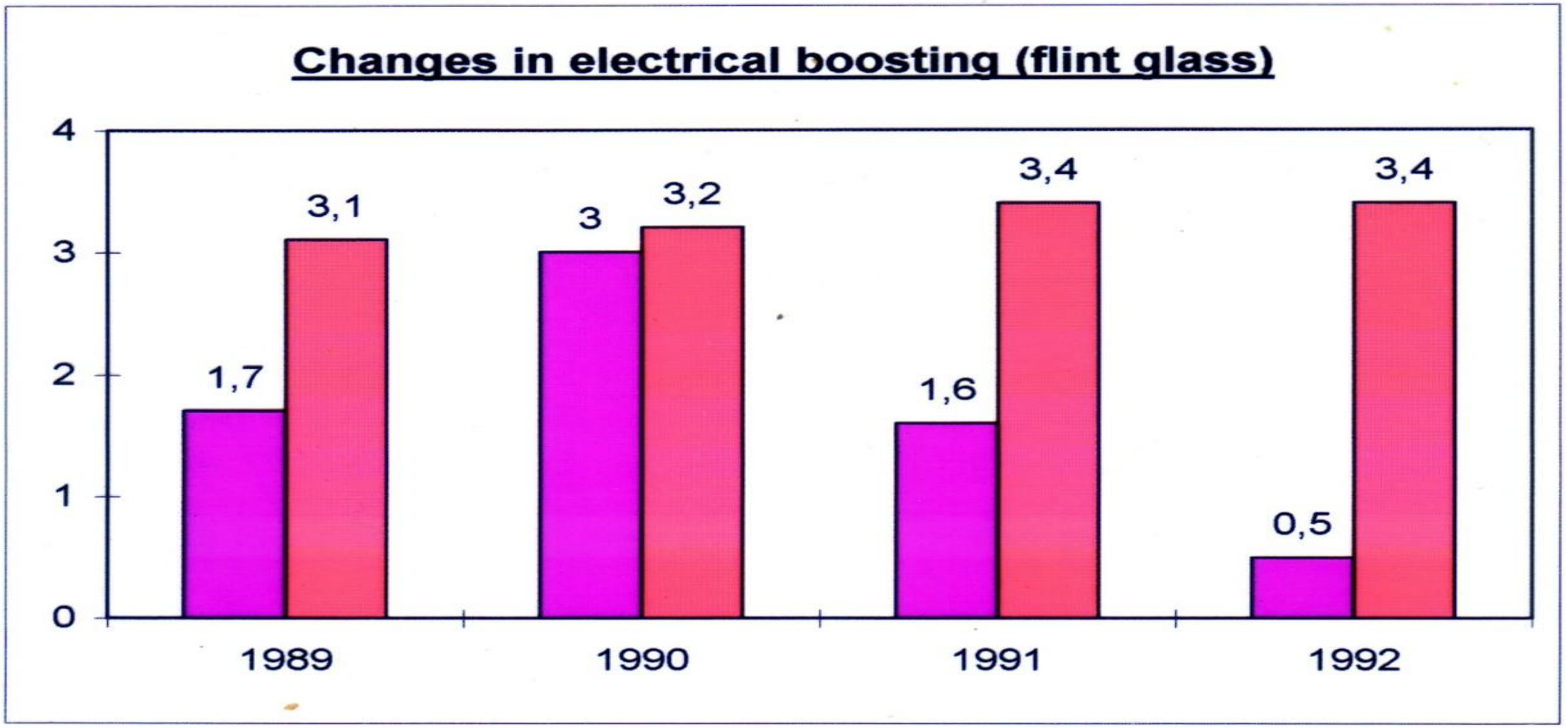
$Ca(OH)_2$ decay about 680 °C: CaO and H_2O

Occurence of the first fluid phase



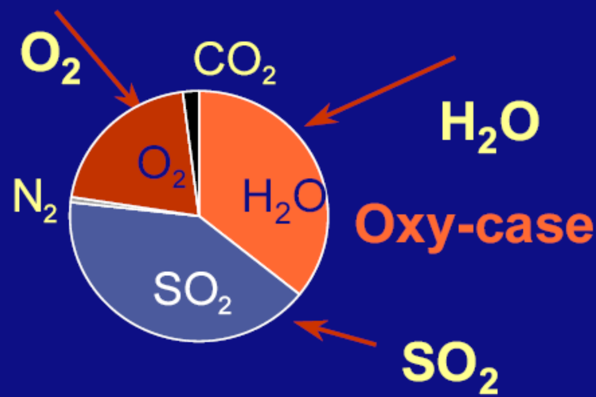


year	1989	1990	1991	1992
kWh/ton	1340	1330	1338	1319
2 % increase/ year (age)	1340	1366	1394	1442



year	1989	1990	1991	1992
Electrical boosting (% of total energy)	1,7	3	1,6	0,5
Pull (t/m^2)	3,1	3,2	3,4	3,4

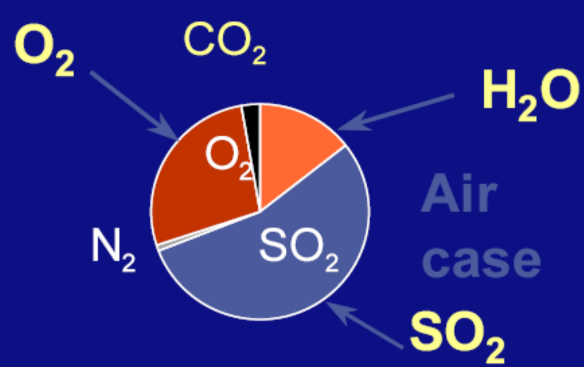
Enhanced Sulfate Fining by Dissolved Water in Melt



In Oxygen fired glass furnace:
p^e_{H2O} = 0.25-0.40 bar

Fining only if:

$p^eSO_2 + p^eO_2$ > **0.70 - 0.75** bar



In Air fired furnace:
p^e_{H2O} = 0.10-0.15 bar

Fining only if :

$p^eSO_2 + p^eO_2$ > **0.9** bar

TNO: Ruud Beerkens

Change of glass composition: CaO increase

Advantages:

Reduced batch free time

Reduced fining temperature

Increased pull rate, reduced energy consumption

Improving the chemical resistance

Batch cost reduction (reduced soda is possible)

Disadvantages:

Changing the length of the glass

Increased liquidus temperature, crystallisation problem (orifice ring)

Solving the problems and using the advantages

„Length“ of the glass – machine speed

Chemical length

- Temperature intervall between two fixed viscosity points

Physical length

- Time to pass a difference in viscosity (according do cooling rate)
- Time for forming
  - Manufacturing by machines: „short“ glass preferred
  - Manufacturing by hand: „long“ glass preferred

Example: silica glass (SiO_2):

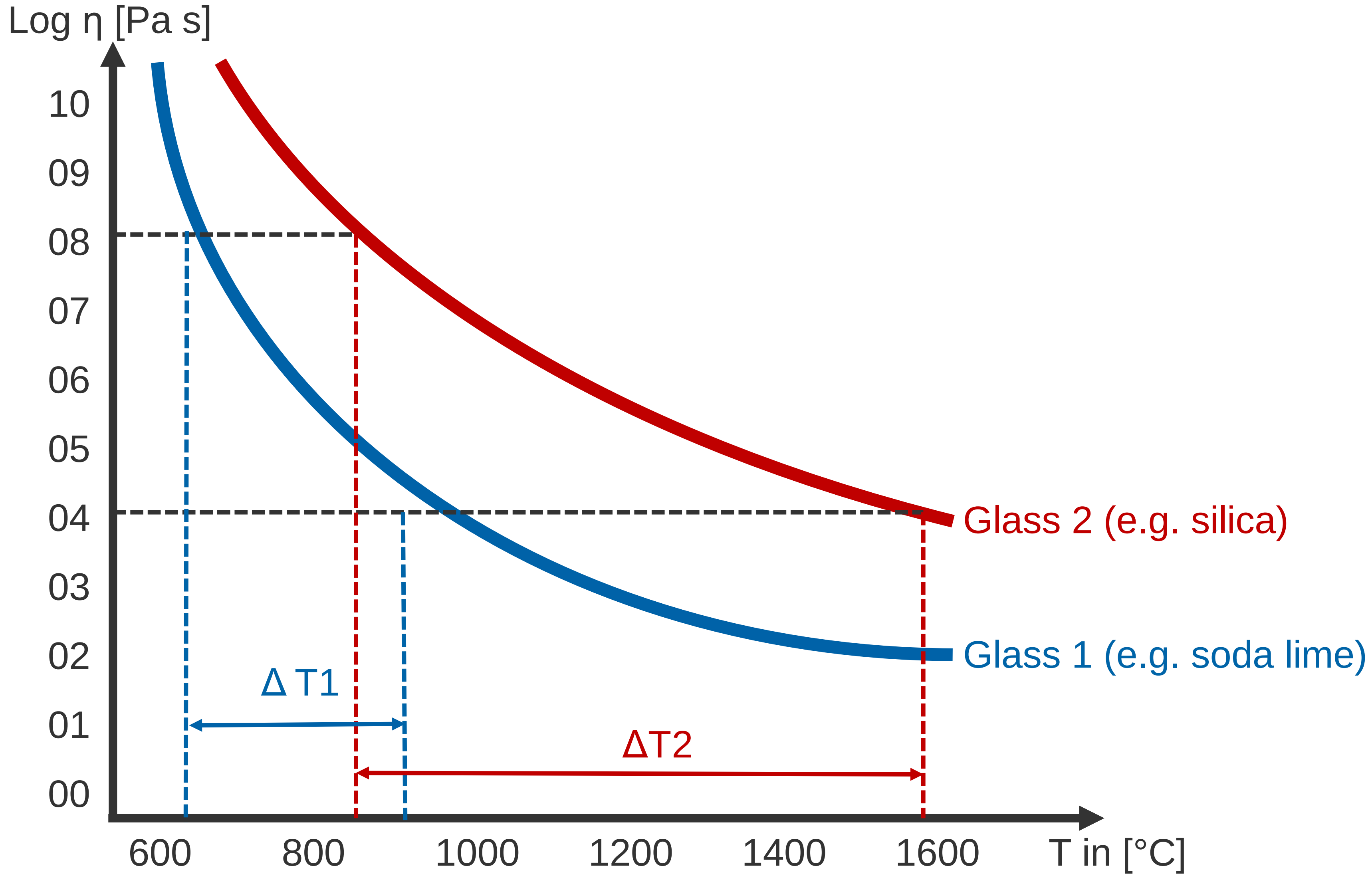
- Little change of viscosity by temperature
- Big change of viscosity by time (radiation heat loss ~ΔT^4)

$$\frac{d\eta}{dt} = \frac{d\eta}{dT} \cdot \frac{dT}{dt}$$

$\frac{d\eta}{dt}$ Change of viscosity by time

$\frac{d\eta}{dT}$ Change of viscosity by temperature

$\frac{dT}{dt}$ Cooling rate



ΔT1 < ΔT2 ➔ Glass 1 is shorter (chemically)

<u>In reality:</u>

Glass 2 is shorter (physically) due to eight times faster cooling rate (radiation ~ ΔT^4)

Potential batch conversion

- crystallization at the orifice ring
  → gob temperature ca. 1150°C
- increasing the lime content
- elimination of the crystallization due to ancorro-technology

composition [in wt. %]	Glass I	Glass II
SiO_2	72.6	71.2
Al_2O_3	1.5	1.5
Na_2O	12.5	11.9
K_2O	0.6	0.6
MgO	2.5	2.5
CaO	10	12
Fe_2O_3	0.04	0.04
SO_3	0.3	0.3
fining temperature [°C]	1465	1445
liquidus temperature [°C]	1038	1093

Glass I: untreated orifice ring

Glass II: orifice ring treated by ancorro

Potential batch conversion

- lowering the batch free time about 33% by increasing of CaO-content
- minimization of the residue quartz dissolution
- same thermal stress of the furnace

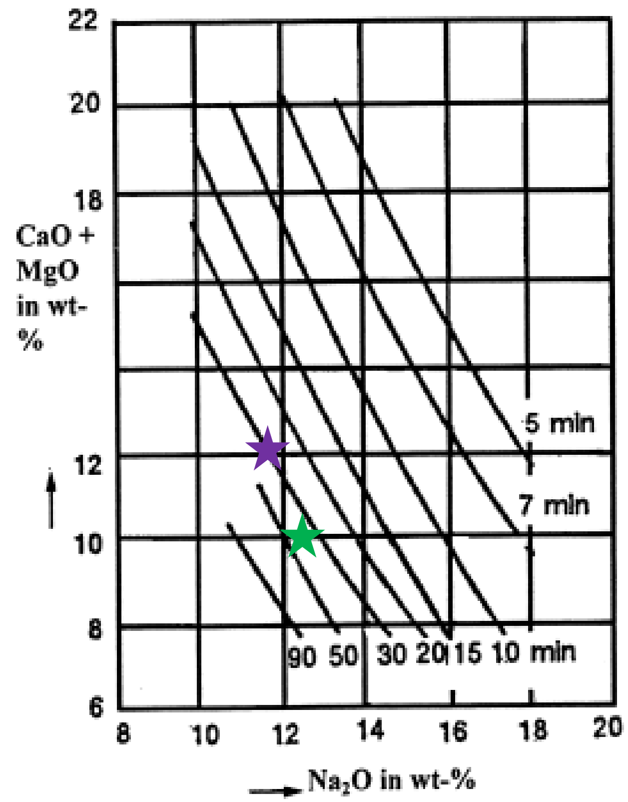
  = increasing of the tonnage

  → rise of capacity

  → depending on forming machines

  → realizable often only for new construction

- increase of turnover about 5.5 million EUR/a possible



Reference: TNO; 1997

Glass I untreated orifice ring

Glass II orifice ring treated by ancorro

Thank you for your attention!