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Leading Thermal Analysis

Kinetic modelling and optimization of firing process of foam ceramics

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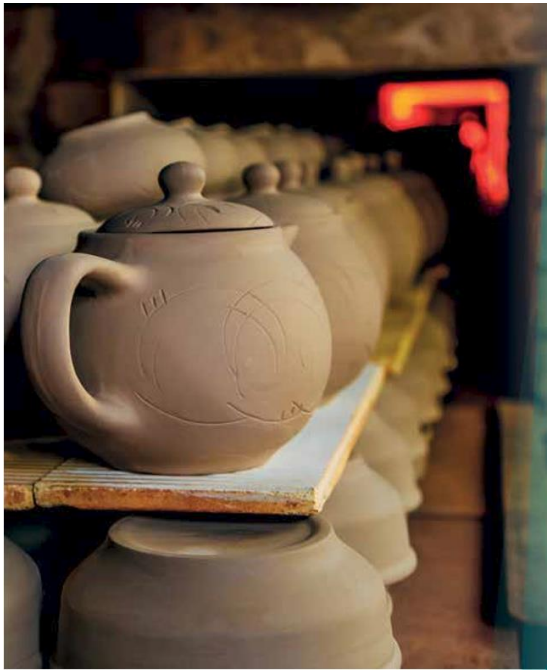
Production: sintering of ceramics

Quality of ceramics depends on the firing temperatures and time
How to improve the quality of product and reduce the production time?



Desired result at unknown production temperature

Photo https://precision-ceramics.com/products/custom-ceramic-parts-components-2/

Corrosion forces revision of the lining, periodicly!

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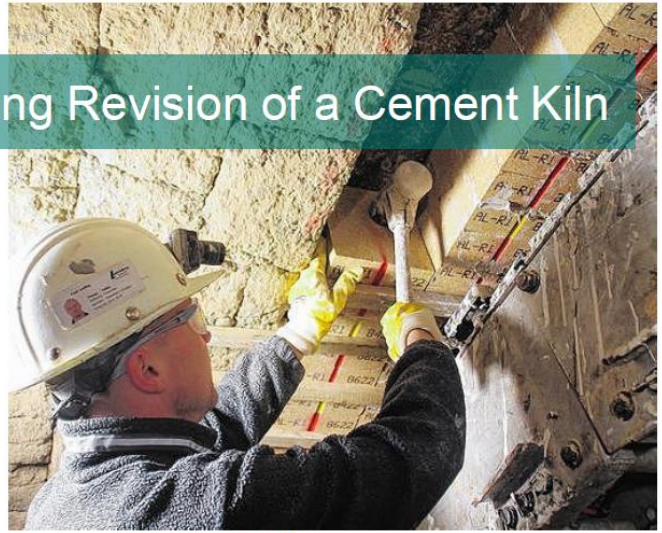
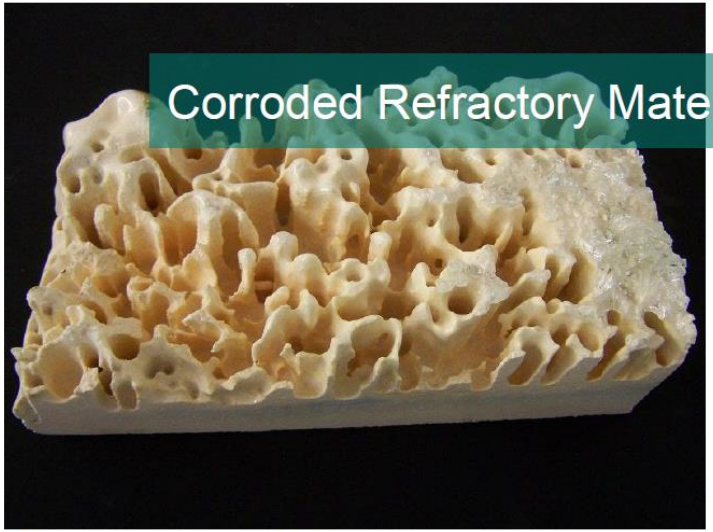


Lining Revision of a Cement Kiln

Source: www.mainpost.de



Corroded Refractory Material

Source: www.physik.uni-halle.de

Main problem: how to reduce the costs?

- Cracks and deformation during sintering of bigger parts
- No exact imagination of the binder-burnout espacially at bigger parts
- MAIN PROBLEM: Long firing-program made the production in larger scale uneconomical

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Optimization of debinding, sintering

How to improve the quality of product and reduce the production time?

KINETICS Neo (+ NETZSCH instruments)

kinetics.netzsch.com

How to solve this problem?

1. Experimental data
   TGA, DIL — *Instrument is necessary*

2. Kinetics Analysis based on experimental data
   Create kinetic model based on experimental data — *Kinetics Neo*

3. Validation of kinetics Model
   Is the simulation in agreement with any existing isothermal data for this process?
   Instrument and Kinetics Neo

4. Prediction or process optimization — *Kinetics Neo*

Short theory

Short theory: Analysis of experimental data

$$\frac{da}{dt} = -A\, f(a,b)\, exp\left(\frac{-E_a}{RT}\right)$$

Known from experiment:

- a,b: concentrations of A and B
- da/dt: reaction rate
- T: temperature

Unknown:

- Ea: Activation energy
- A: pre-exponential factor
- f(a,b): reaction type

Analysis: to find **kinetic model** (Ea , A, f(a,b)) from experimental data

Short theory: Simulation for given temperature

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$$\frac{da}{dt} = -A\, f(a,b,Tg)\, exp\left(\frac{-E_a}{RT}\right)$$

Known from experiment:

- a,b: concentrations of A and B
- da/dt: reaction rate
- T: temperature

Known from Analysis:

- Ea: Activation energy
- A: pre-exponential factor
- f(a,b): reaction type

Simulation:

- T: given user's temperature
- Unknown da/dt: reaction rate
- Unknown
  Tg : glass transition temperature
  a,b: concentrations of A and B

Analysis: Kinetics model Ea , A, f(a,b) is found from experimental data

Simulation: to calculate da/dt, a,b, Tg for user's defined temperature T(t)

Short theory: Optimization of the process

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$$\frac{da}{dt} = -A\, f(a,b)\, exp\left(\frac{-E_a}{RT}\right)$$

Known from experiment:

- a,b: concentrations of A and B
- da/dt: reaction rate
- T: temperature

Known from Analysis:

- Ea: Activation energy
- A: pre-exponential factor
- f(a,b): reaction type

Simulation:

- Known da/dt: reaction rate
- Unknown T: process temperature

Analysis: Kinetics model Ea , A, f(a,b) is found from experimental data

Optimization: to find T(t) for user's defined reaction rate da/dt

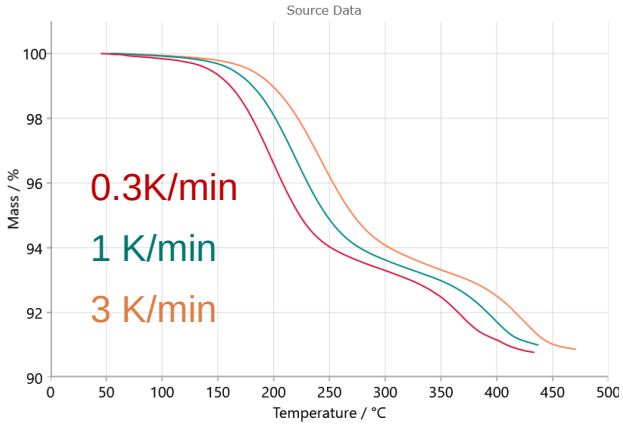
Sintering optimization

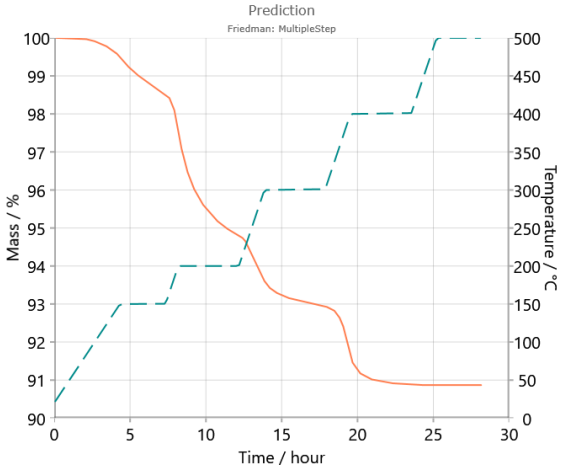
Two processec during firing: debinding and sintering

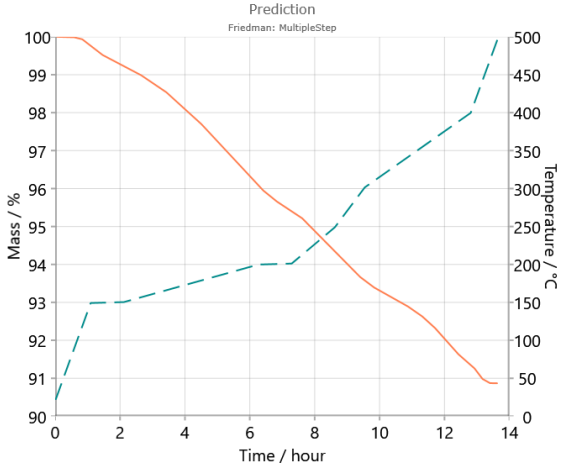
A Thermobalance gives you information about the binder burnout!

A Dilatometer gives you information about the sintering shrinkage and thermal expansion!

Debinding: Optimization based on STA data







Example of measured data for debinding

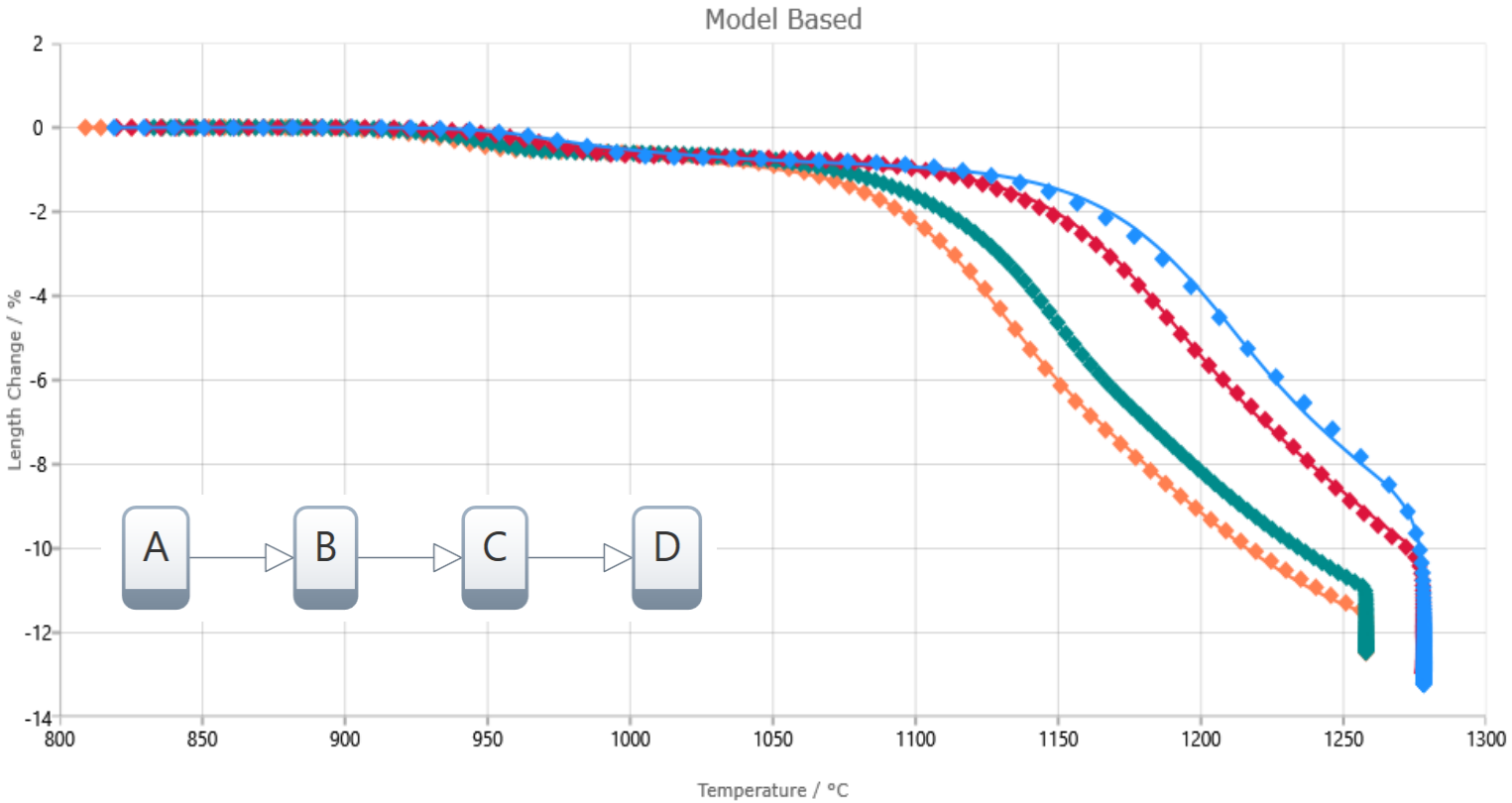
Original temperature program:

Bad quality and long time

Optimized temperature program:

Improved quality and short time

Example of sintering process: DIL Data and kinetic model



0,5K/min

1 K/min

5 K/min

10 K/min

Example: porcelain.

Temperature optimization for constant sintering rate

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How to improve the quality of product and reduce the production time?

Properties

ConversionRate Optimization Properties

Method / Model

t:;

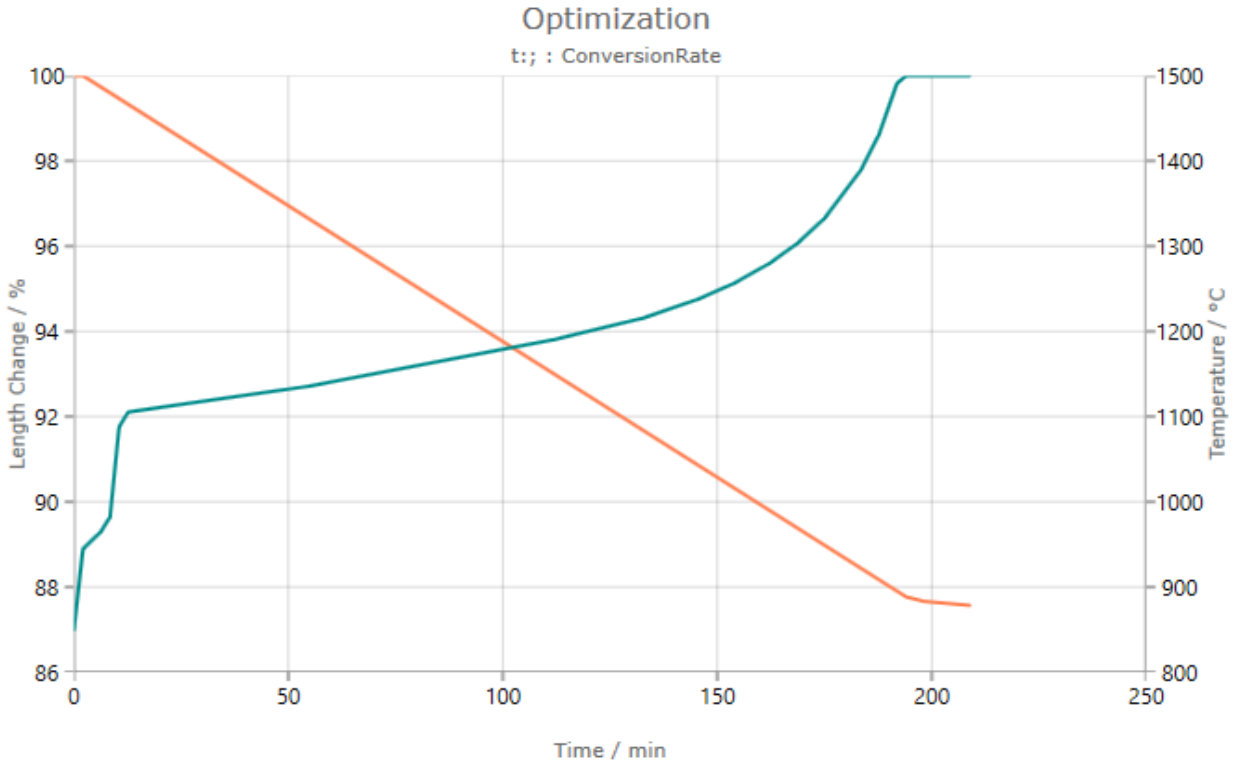
Minimal Temperature	850,00	°C
Maximal Temperature	1500,00	°C
Minimal Heating Rate	-5,00	K/min
Maximal Heating Rate	50,00	K/min
Conversion Rate	0,50	%/min

Calculate

☑ Show Temperature program

Isoconversion Curves

All | None | Default | Custom



Kinetic Neo calculates optimal sintering temperature program for given sintering rate 0.5%/min

New material

HALFOAM ALUMINA ™

by

Morgan Advanced Materials
HALDENWANGER

Production time was reduced by more than 50%

We allow to tell story about the optimization of production process

Production time was reduced more than by 50%

Additional information is on *kinetics.netzsch.com*