Nabaltec

INFLUENCE OF CALCINED AND REACTIVE ALUMINAS ON THE RHEOLOGY AND THERMOMECHANICAL PROPERTIES OF LOW-CEMENT CASTABLES

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- Summary
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We need some sub-µm Particles

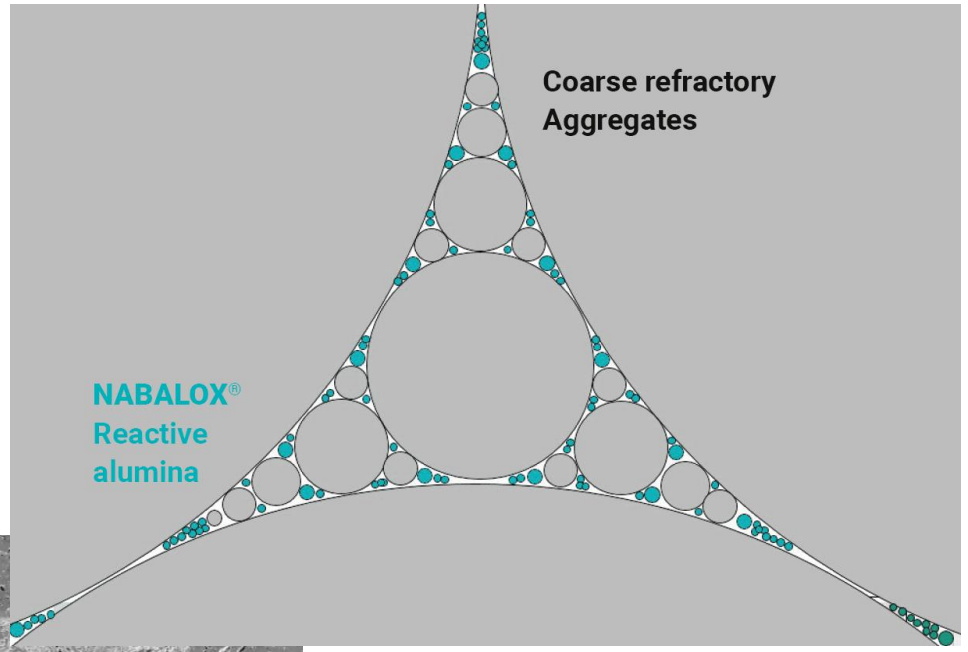
Microfillers to increase particle packing

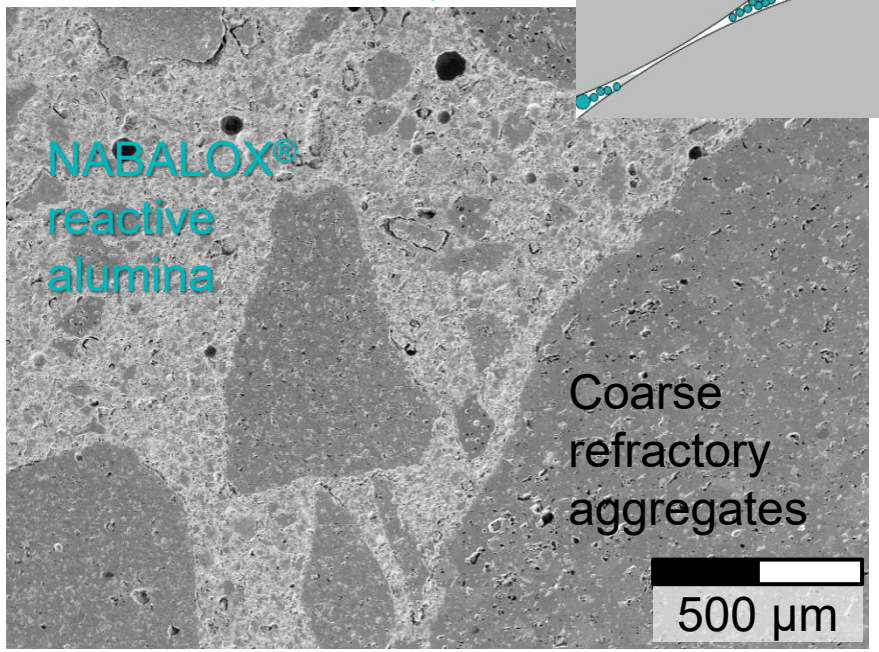
- ⬇ water demand
- ⬆ packing density
- ⬆ strength
- ⬆ refractoriness
- ⬇ creep
- ⬇ corrosion

Refractory microstructure

in theory

in reality





Reactive Alumina or Micro Silica?

Does the refractory castable already contain SiO_2?

NO · silica-free system

YES · e.g. due to bauxite

	REACTIVE ALUMINA		MICRO SILICA
Particle size	0,5 – 2,5 µm		0,1 –0,3 µm
SSA	1,5–9 m²/g		16–20 m²/g
True density	3,98 g/cm³		~ 2,5 g/cm³

Tabular Alumina based castable	
Raw material	**[%]**
Tabular Alumina 3 – 6 mm	24
Tabular Alumina 1 - 3 mm	16
Tabular Alumina 0,6 – 1 mm	15
Tabular Alumina 0 - 0,6 mm	11
Tabular Alumina 0 – 45 µm	15
NO 115 TC	8
Reactive Alumina	6
CAC (Secar 71)	5
Viscocrete 225 P	0,1

Bauxite based castable	
Raw Material	**[%]**
Bauxite ”RASC” 3 – 5 mm	35
Bauxite ”RASC” 1 – 3 mm	10
Bauxite ”RASC” 0 – 1 mm	19
Bauxite ”RASC” 0 – 90 µm	19
Calcined Alumina	6
Microsilica RW Füller Q1	6
CAC (Istra 50)	5
Viscocrete 430P	0,14

Reactive Alumina . . . but which one?

NABALOX®	distribution	D_{10} [µm]	D_{50} [µm]	D_{90} [µm]	SSA (BET) [m²/g]
AOR EXS 34-17	bimodal	0,4	1,7	4,1	4,7
NO 530	bimodal	0,4	2,1	5,2	4,0
NO 645	bimodal	0,5	2,4	5,3	3,8
NO 640	bimodal	0,5	2,8	6,6	3,4
NO 625-30	bimodal	0,5	2,2	5,0	3,7
NO 652	bimodal	0,8	3,1	6,5	2,7
NO 660	bimodal	0,6	2,1	4,1	3,1
NO 550 P	trimodal	0,7	3,4	27,8	2,1
NO 625-10	monomodal	1,5	3,1	5,2	1,5
NO 325*	monomodal	1,8	3,9	8,8	1,2

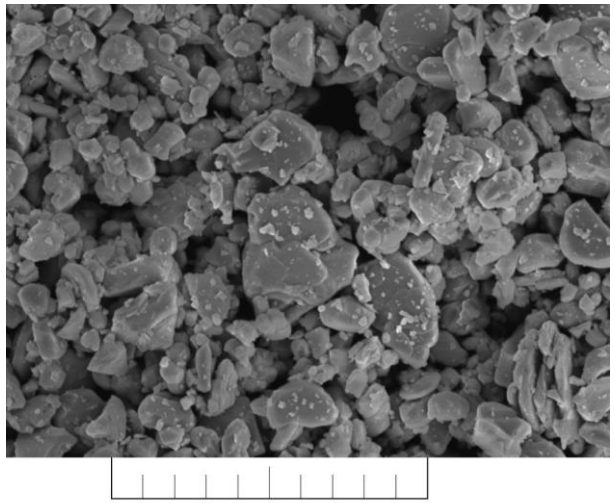
* Not reactive

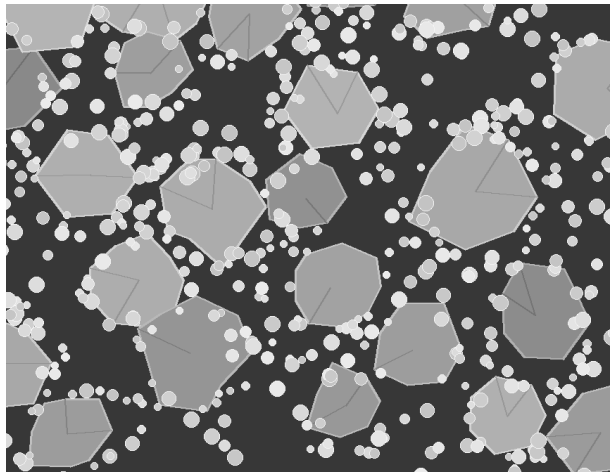
Reactive Aluminas of three different kinds

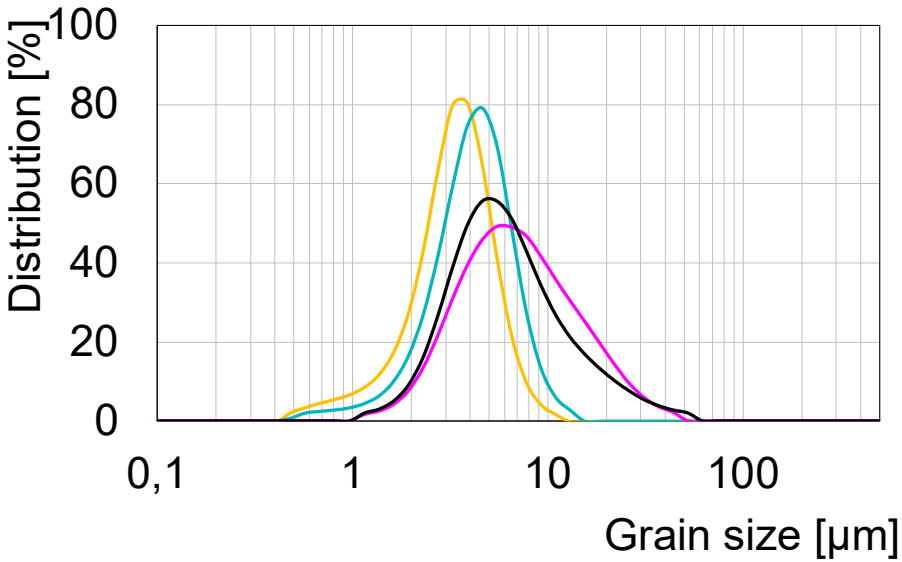
PSD models

Monomodal (Reactive) Aluminas

- „Reactive“:
  - D50 < 3 µm
- Specific Surface Area(BET):
  - 0,8 – 1,5 m²/g
- Almost no particles < 1 µm
- Combination with Microsilica to from a bimodal Matrix







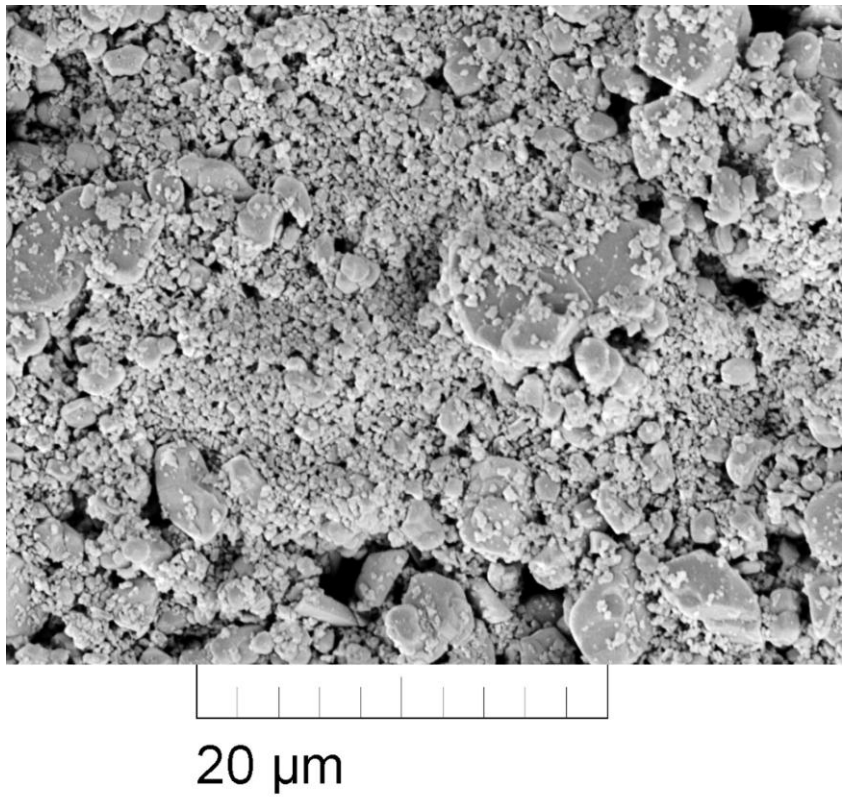
Aluminas used for the Bauxite based castable

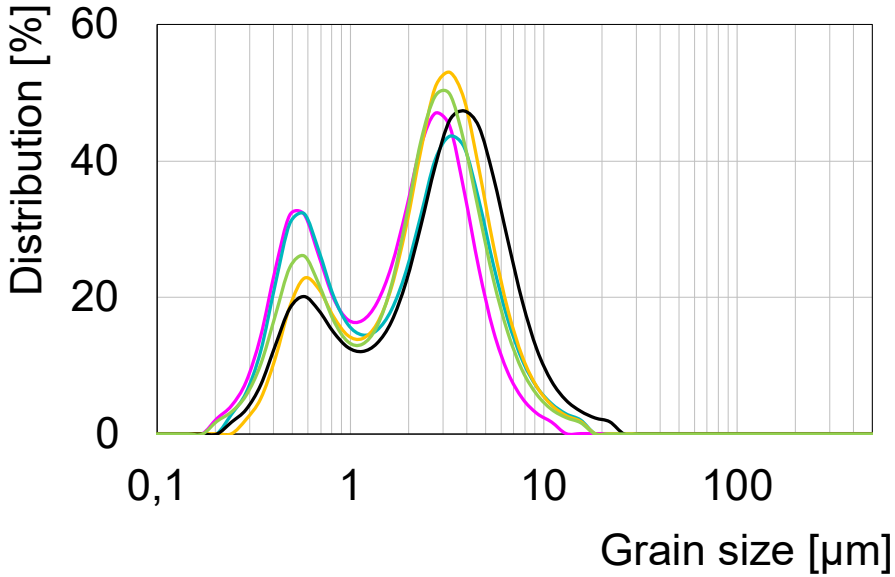
Reactive Aluminas of three different kinds

PSD models

Bimodal Reactive Aluminas

- Particle sizes:
  - 2 µm
  - 0,5 µm
- Bimodal matrix with only one raw material





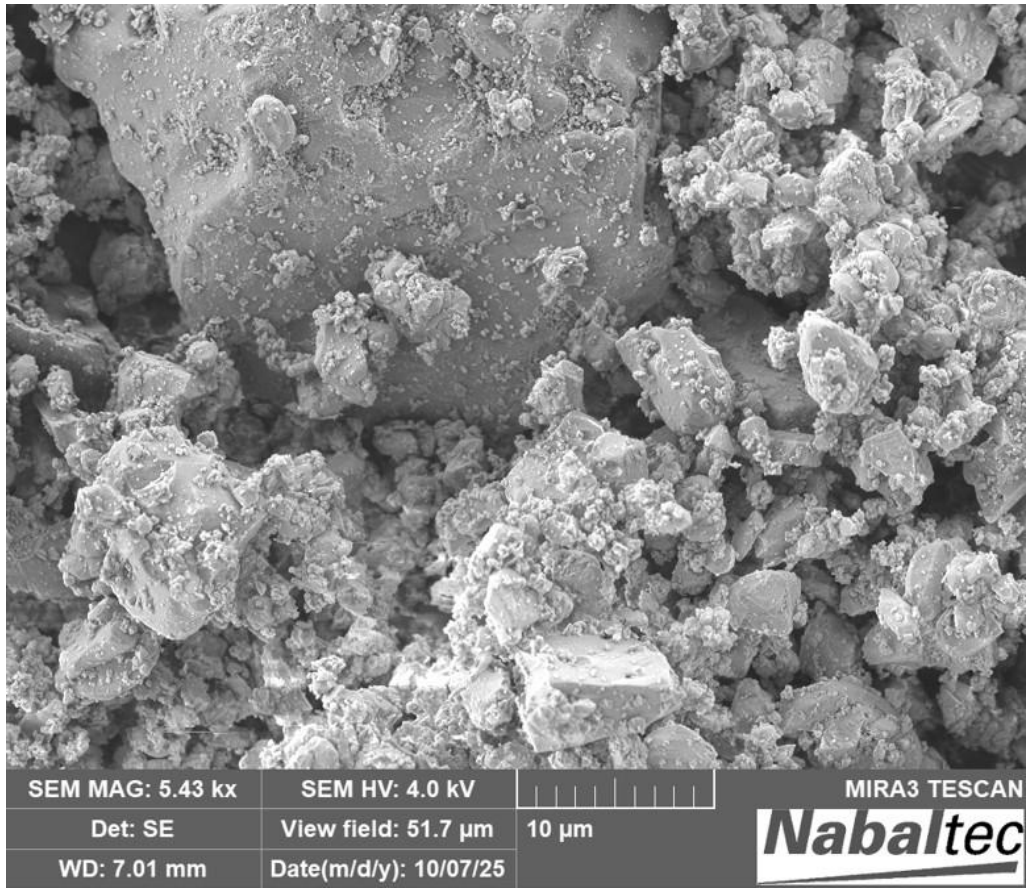
Aluminas used for the Tabular Alumina based castable

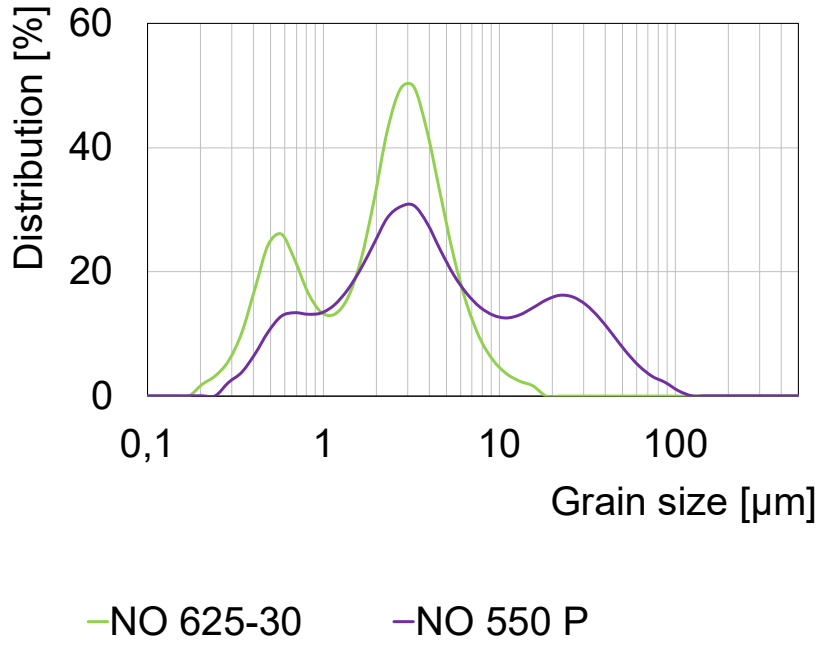
Reactive Aluminas of three different kinds

PSD models

Trimodal Reactive Aluminas

- Particle sizes:
  - 20 µm
  - 2 µm
  - 0,5 µm





Bimodal and Trimodal Reactive Almina in comparison

Mixer Power consumption monitoring

- Viscosity at low(er) shear rate:
  - Flow spread

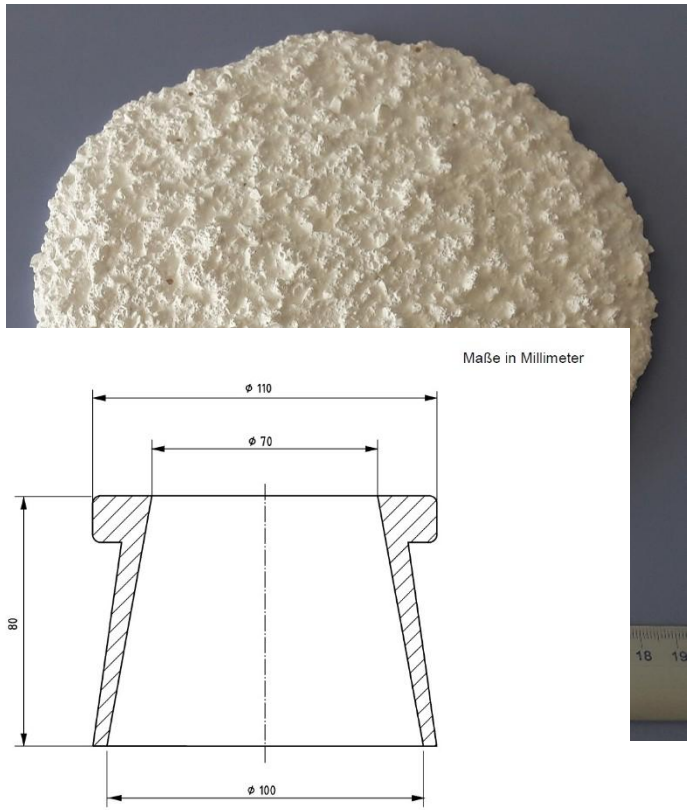


Bild 2 — Trichterform 2, Höhe 80 mm

DIN EN ISO 1927-4:2012

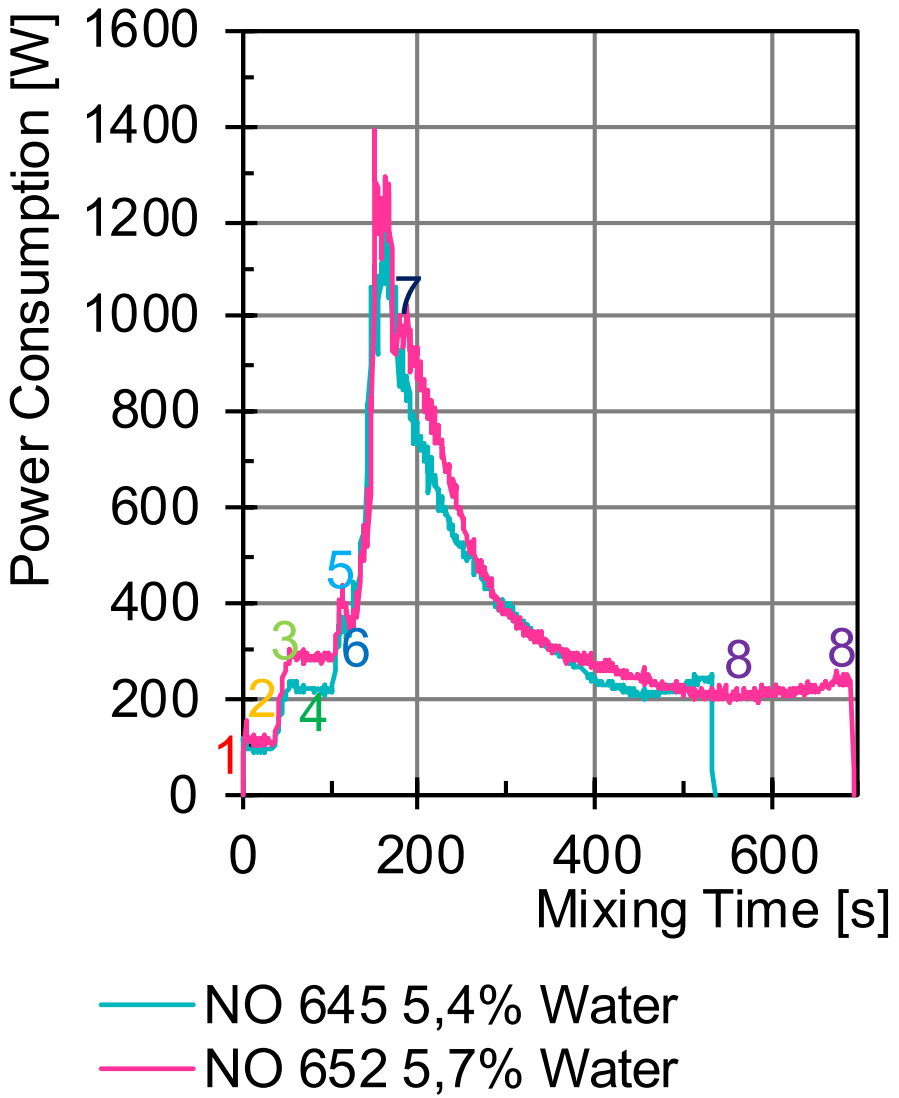
- Viscosity at high(er) shear rate
  - Mixer power consumption monitoring

Self created;
details in the paper

- Conclusions to be drawn about viscosity
- Flow spread is inversely (!) proportional to viscosity
- Relevant for real usecases
  - Mixing
  - Casting

A new approach to the P-t-plot

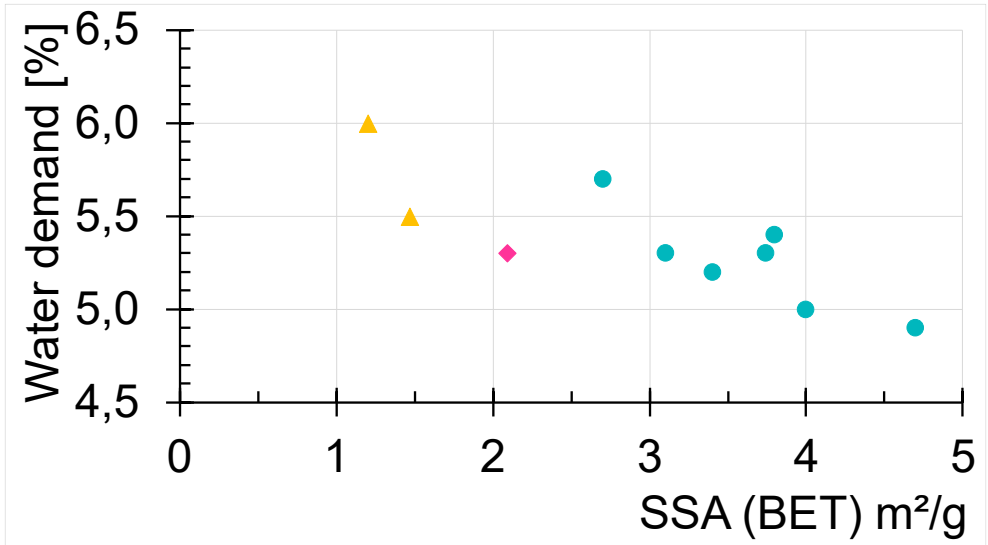
1 (0 s)	Filling of 5 kg of dry castable premix into the bowl
2 (30 s)	Dry mix
3 (30 s)	Add 3.5 % water
4 (60 s)	Semi wet mix
5 (15 s)	Add another 1,0 % water
6 (15 s)	Semi wet mix
7 (15 s)	Addition of water until P has passed the Maximum and decreased below 900 W
8 (till end)	Stopped when P has passed the Minimum and a clear upturn is visible.

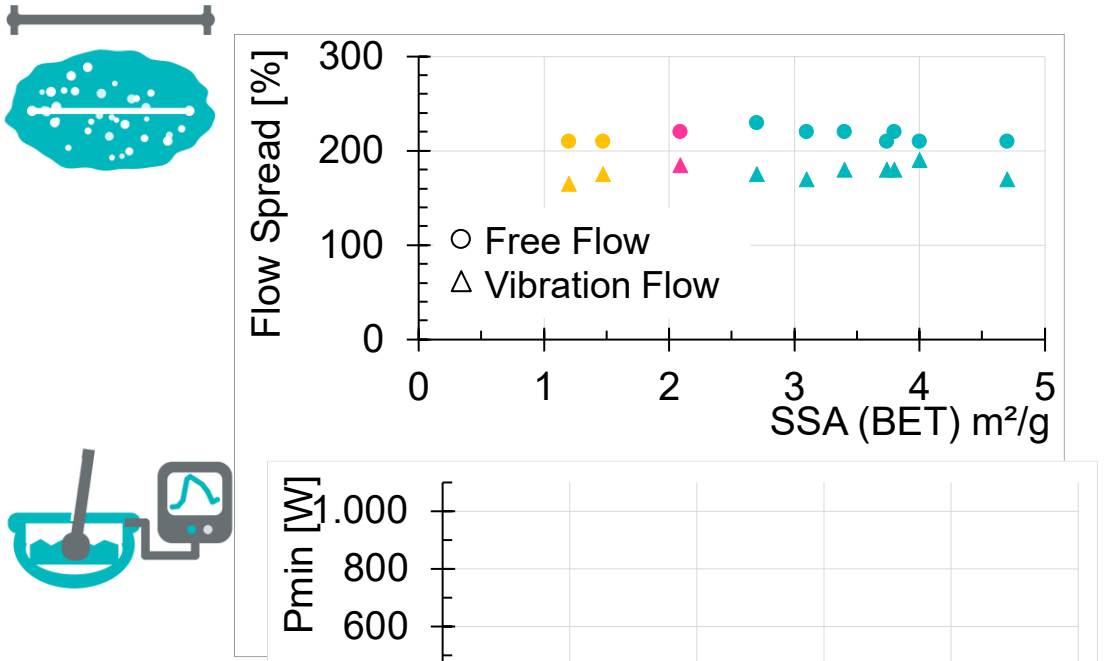


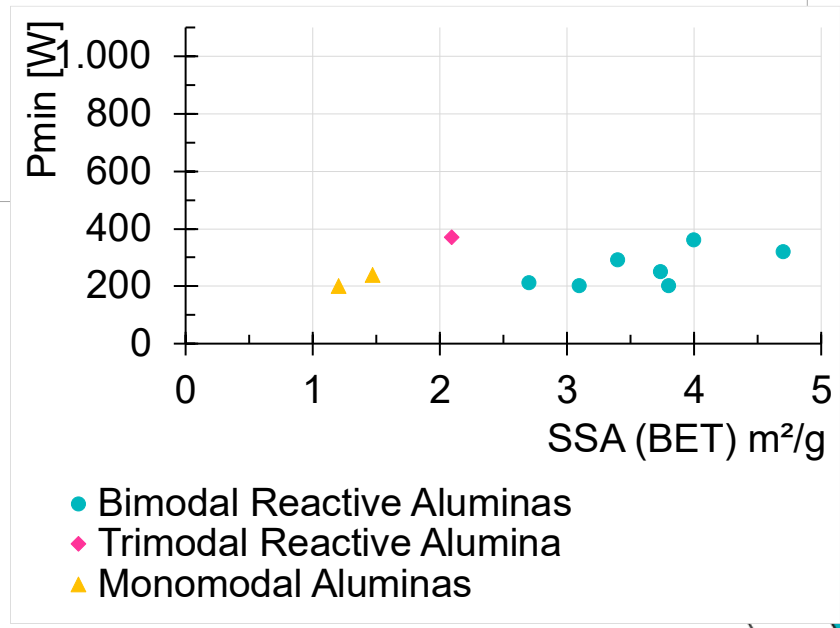
- Water demand
- Flow spread
- CCS, apparent Density
  - 25°C
  - 110°C
  - 1000°C
  - 1500°C
- PLC
  - 1000°C
  - 1500°C

Results – Water demand and rheology

Corundum based castable





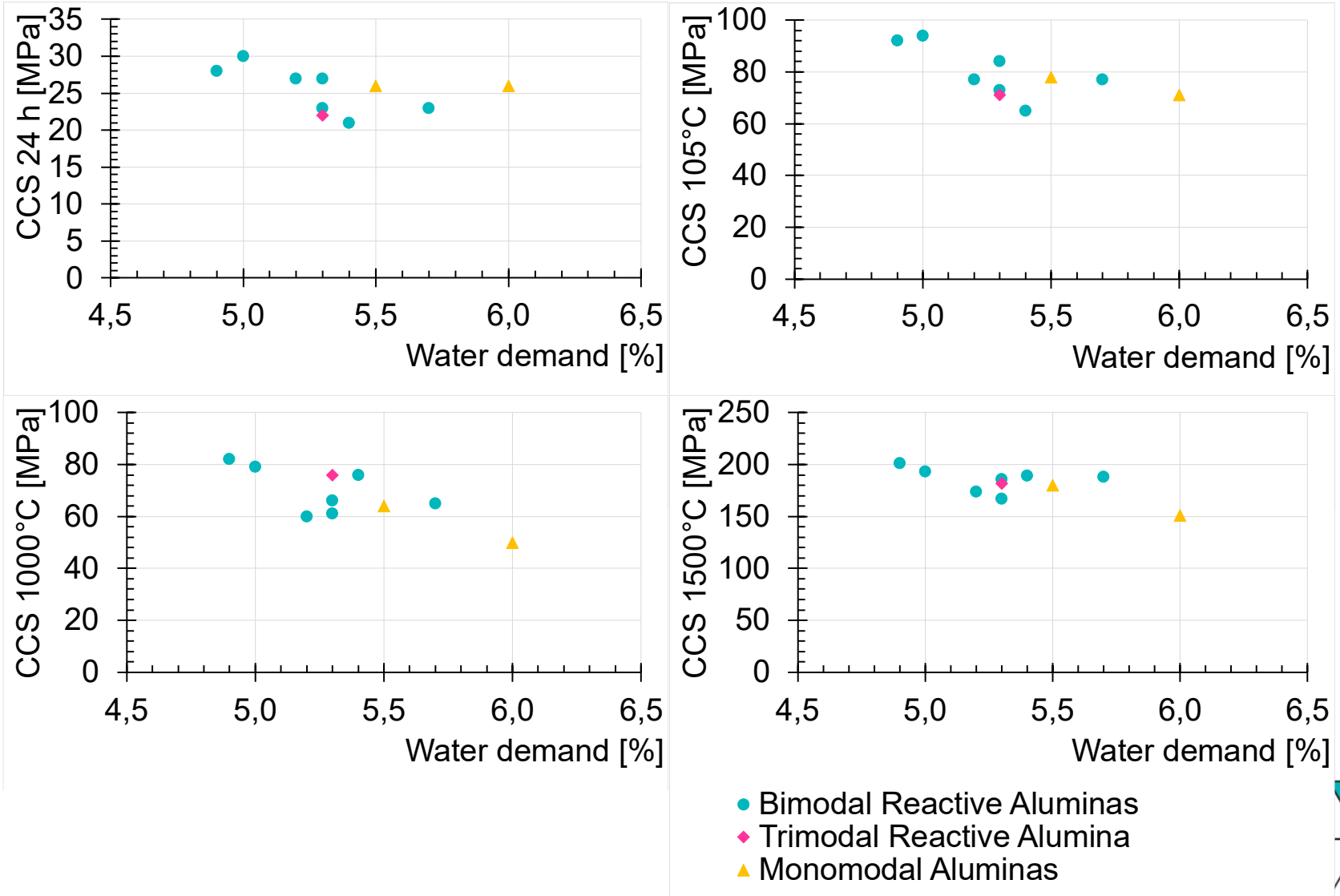


- Significant water reduction
- Similar Viscosity at low and high shear Rate

Results – Strength

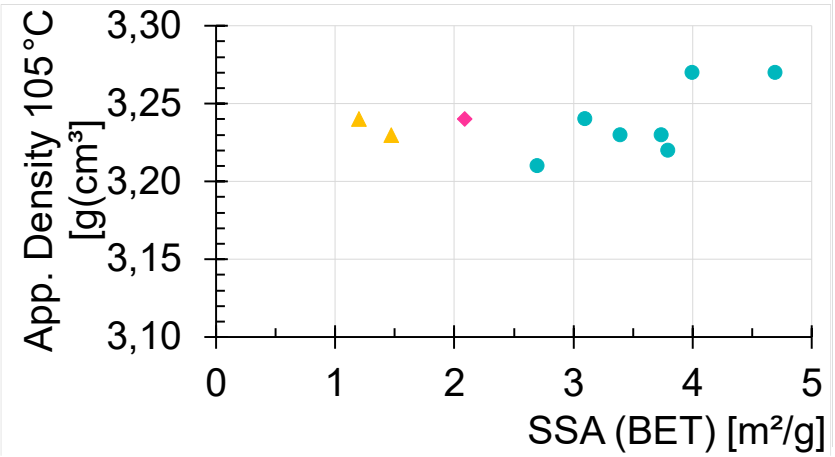
Corundum based castable

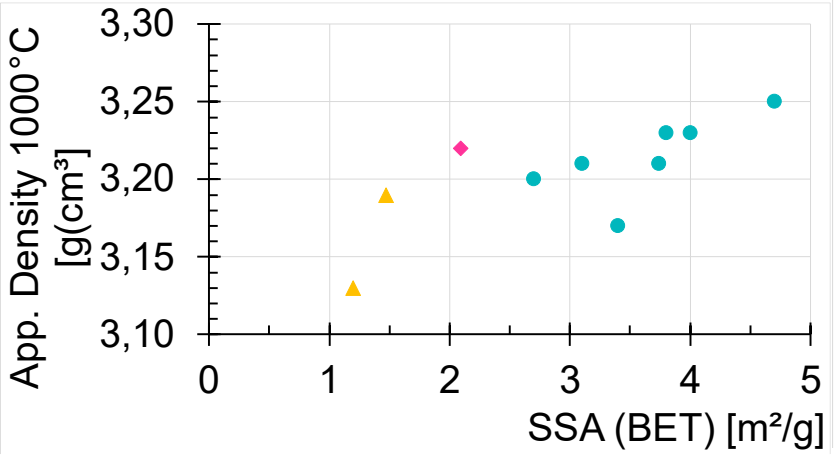
- Density increases with lower water demand
- Cold crushing strength increases with increased density
- Also after sintering

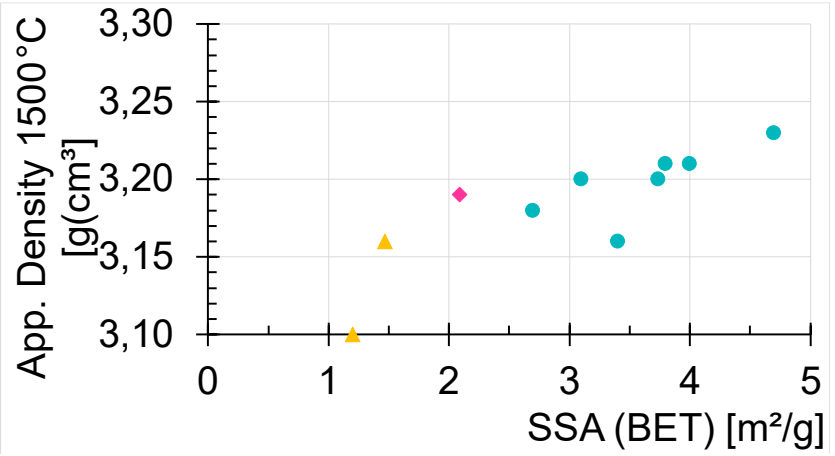


Results – Thermo mechanical properties

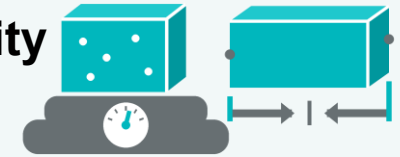
Corundum based castable



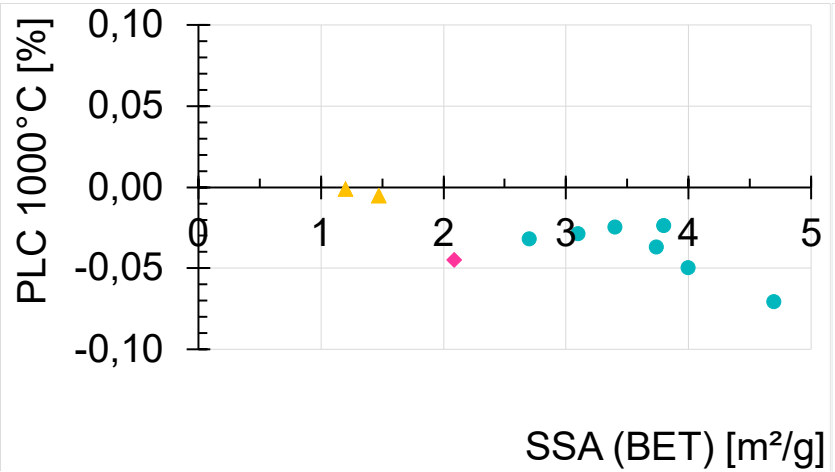


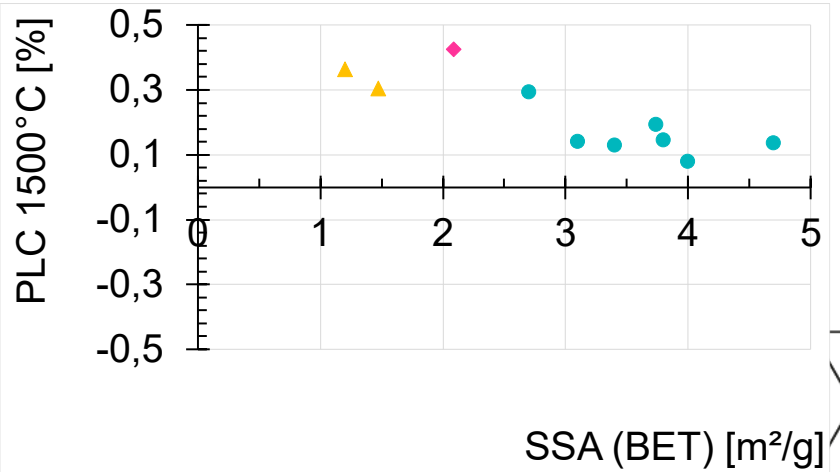


Density



- by dehydration of CAH-Phases
- CA_6- formation
- by sintering-shrinkage

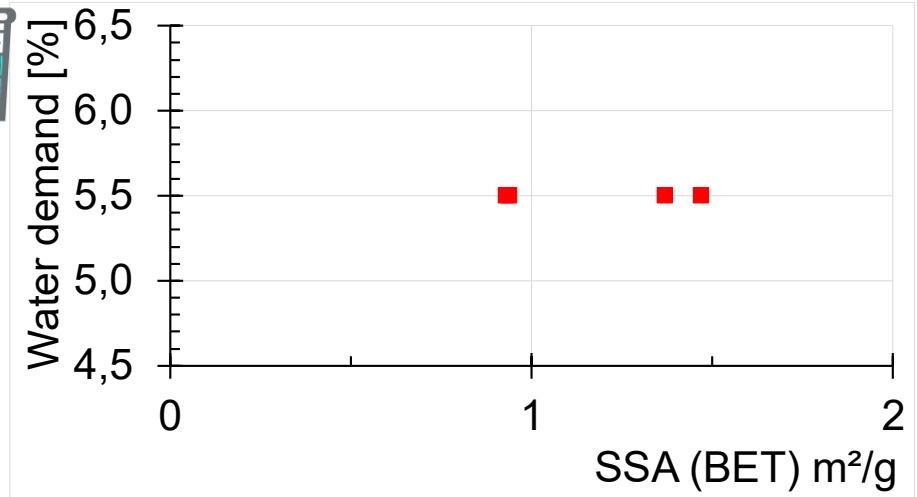


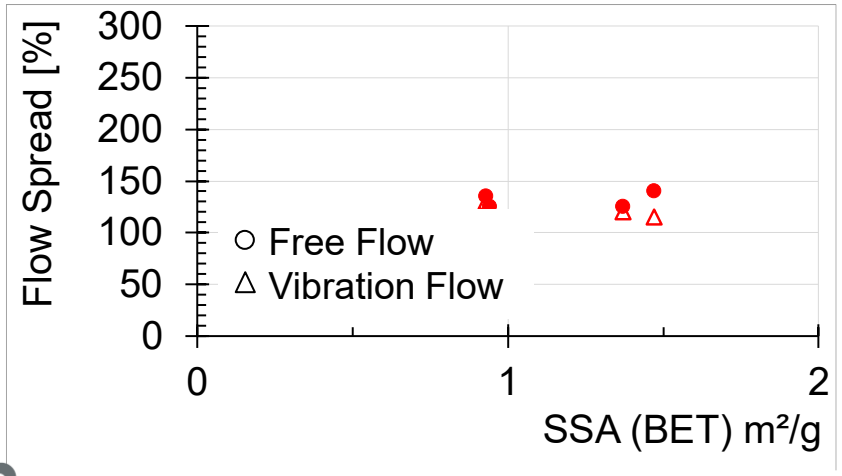


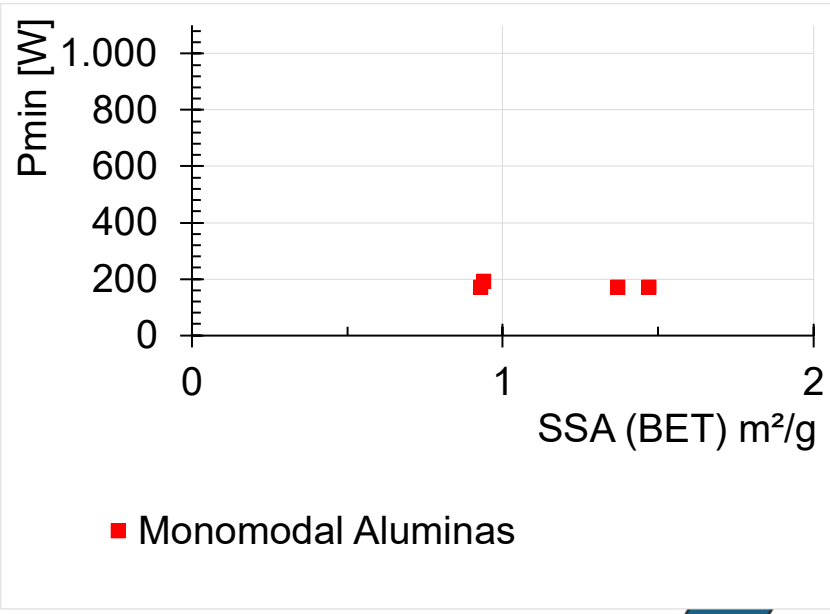
- Bimodal Reactive Aluminas
- Trimodal Reactive Alumina
- Monomodal Aluminas

Results – Water demand and Rheology

Bauxite based castable







- \+ No effect on water content and rheology
- → No effect on strength and thermomechanical properties expected

Summary

- Mixer power consumption monitoring as a tool to adjust the water content of a castable to the desired consistency
- If Reactive Alumina is the finest component,
  - Bimodal Alumina with high Specific Surface provide low water demand and higher shrinkage
  - Trimodal Alumina provides low water demand and less shrinkage
  - Monomodal Alumina provides higher water deamand and lower shrinkage
- If Reactive Alumina is not the finest component,
  - Properties are still dominated by the finest component

Outlook

- Mixer power consumption monitoring is used as a tool
  - for ongoing improvement of our products
  - for the development of new products with superior theological properties

Thank you for your attention

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