The effect of refractory quality on glass defects: Testing and sampling of refractories

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Commercial Glass Types

Flat Glass

E-Glass (Fibre)

Container Glass

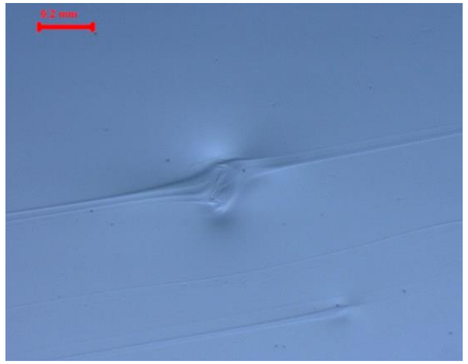
Tableware Glass

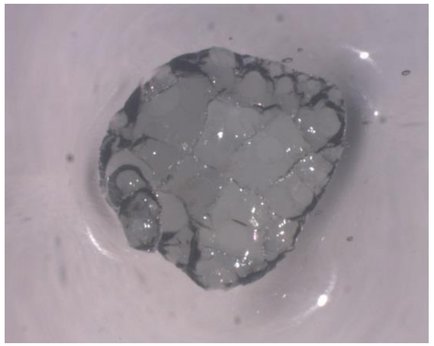
Glass failure causes and types

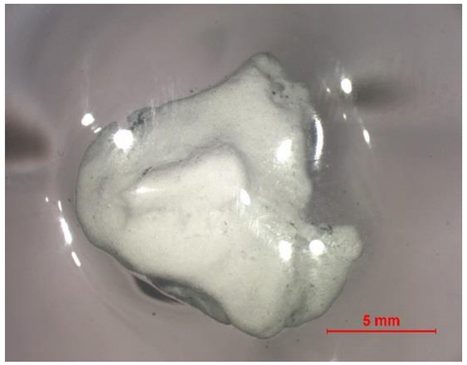
As source
- Raw Materials (Batch-Cullet)
- **Refractories**
- Melting process (Devitrification/Unsufficiant Melting)
- Forming
- Annealing
- Stock conditions
- Second Process

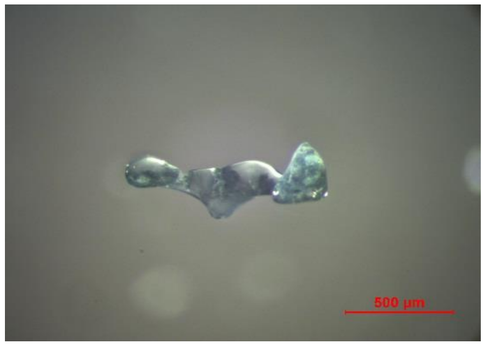
As structure
- Amorphous (Glassy)
- Crystaline

As Type
- Stone
- Knots
- Cords
- Metallic Inclusion
- Bubles
- Cystals

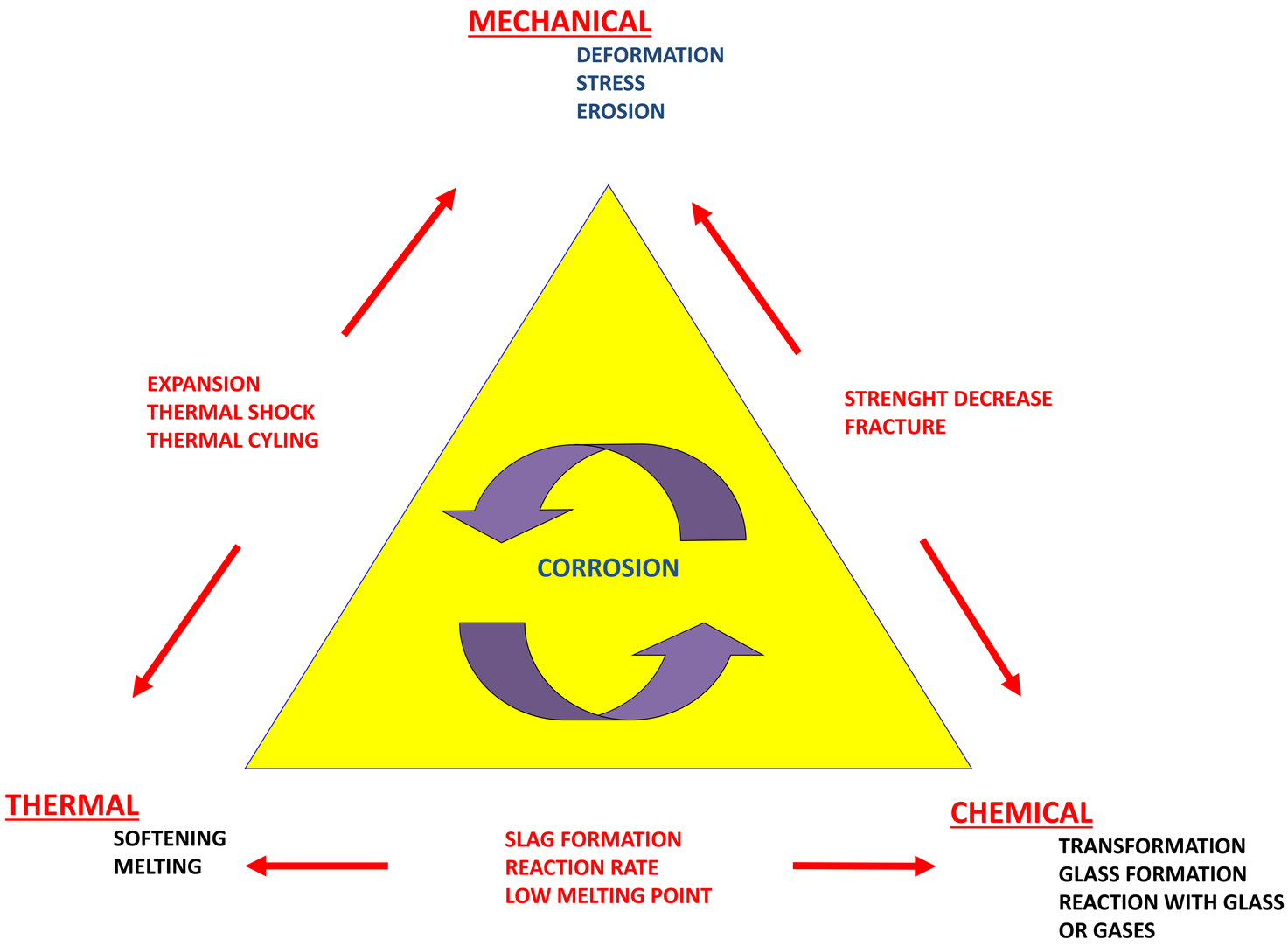








The effects on glass furnace refractories



Glass melting refractories defect potential

Refractory Type	Location in Furnace	Defect Potential
Silica	Melter and working end Crown, Melter refining and working end Superstructure	Silica refractory stone, Silica rundown/ drip, Frost
Alumina	Melter superstructure (float), A wall (Float), Waist crown (Float), Forehearth canal /superstructure (container, tableware)	Aluminous stone, cord
Mullite	Regenerator walls, waist crown	Aluminous stone
Silimanite	F/H cover block	Aluminous stone/cord
Zircon	Isolation between alumina / silika Mortar, Monolithics	Zircon stones
Fused cast AZS	Melter sideblocks, Melter tuckstones, Melter pavings, Melter superstructure	AZS stone (AZS1,AZS2) , AZS knots, cords
Magnesia	Regenerator walls, crowns, checkers	Spinel

Testing and Sampling

Characterization;

1- Chemistry-XRF
2- Phase distribution-XRD
3- Microstructure -Microscopic tecniques – Light/SEM
4- Density/Porosity

Testing

AZS
1- Exudation
2- Static Cor.
3- Dynamic Cor.
4- Blistering

Testing

Fused Cast Alumina
1-Static Cor.
2-Dynamic Cor.
3-Vapor attack
4-Blistering

Testing

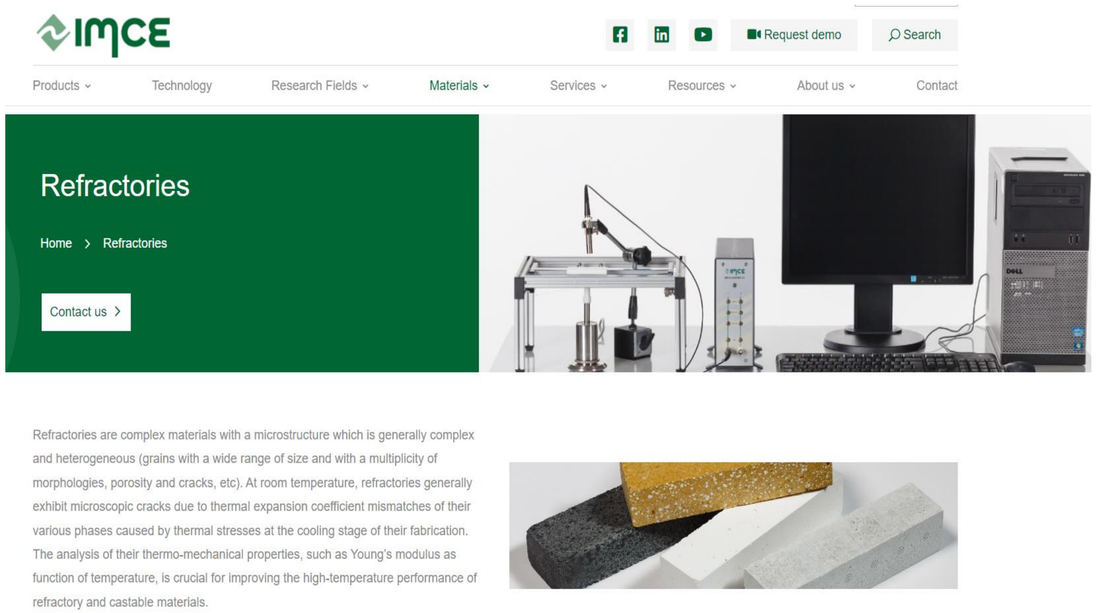
Silica
1- CCS
2-Creep/HMOR/RUL
3- Vapor Attack
4- Sulphate Attack

Testing

Other types bonded
1- CCS
2- Creep/RUL/HMOR
3-Vapor Attack

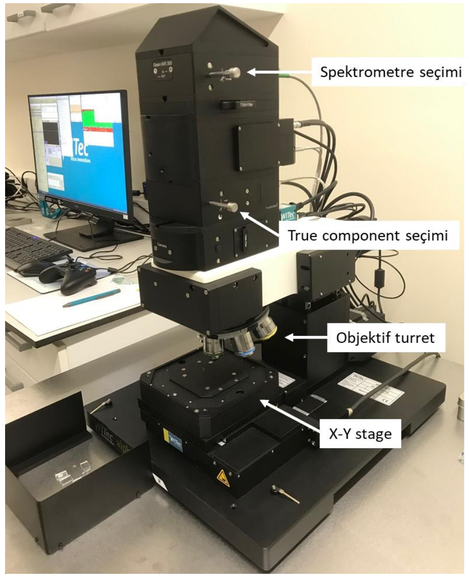
New perspectives for characterization

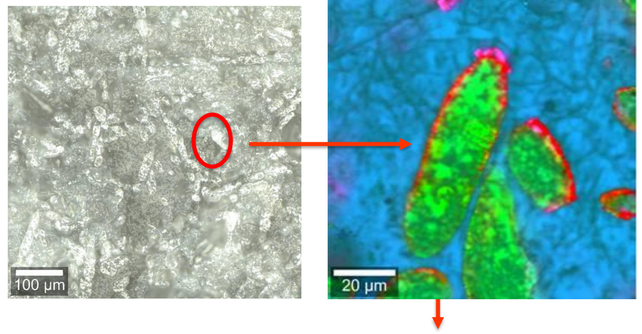
RFDA method for refractory control

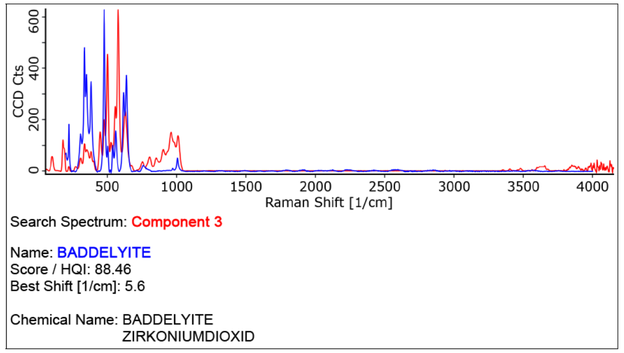


The RFDA algorithm utilizes an iterative process that analyzes the sample's natural frequencies with high accuracy

Raman Spectroscopy



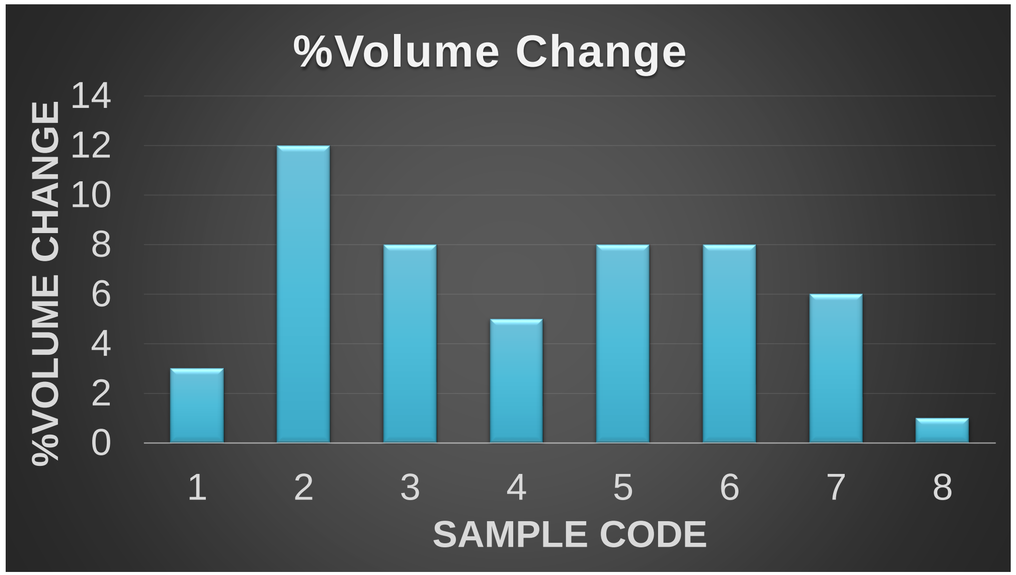




Raman spectroscopy is an analytical technique where scattered light is used to measure the vibrational energy modes of a sample

Exudation Test for AZS Refractories

- Prepare the cylindrical refractory samples having Ø32mm radius and 10 mm height,
- Measure volume before the test
- Put them in a furnace and set 1500ºC for 16 hours,
- Calculate the Volume difference



Exudation	Volumetric change must be less than 2,5% (2,5% ≤ DV).

Sample 1

Sample 2

Sample 3

Sample 4

Sample 5

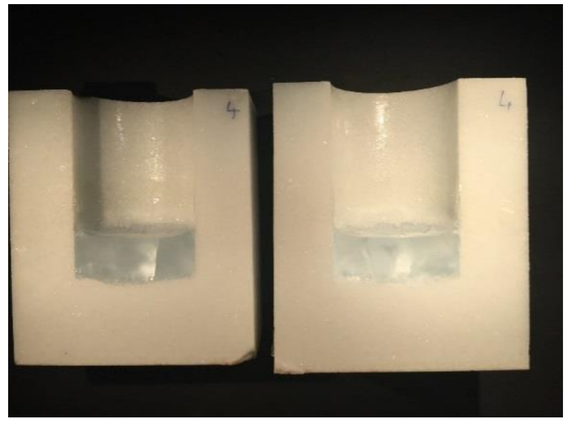
Sample 6

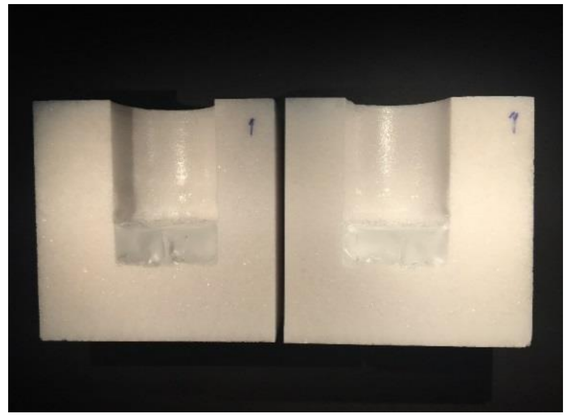
Sample 7

Sample 8

Static Corrosion Test for Alumina/AZS Refractories

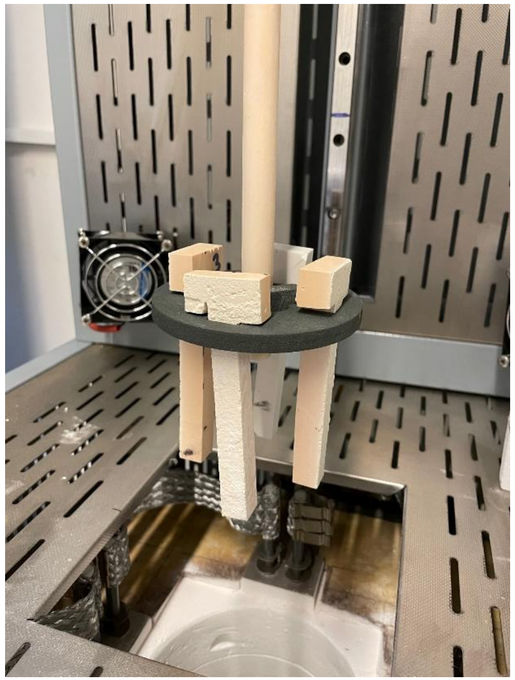
- Aggressive (%75 SiO_2, %20 Na_2O, %5 Na_2SO_4,) batch is used,
- Drill a hole in refractory cube samples so that the aggressive batch can be put in,
- Put it into the furnace and set the temperature 1450^0C'for 48 hours.

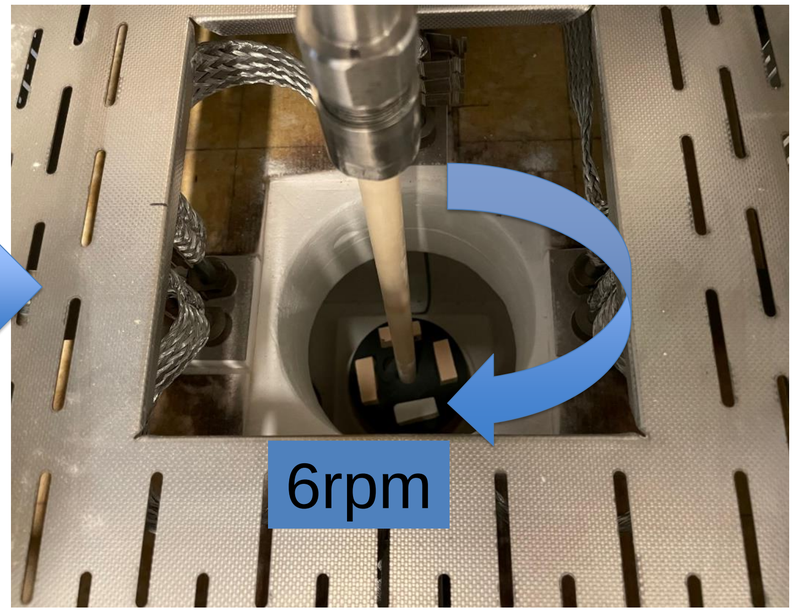


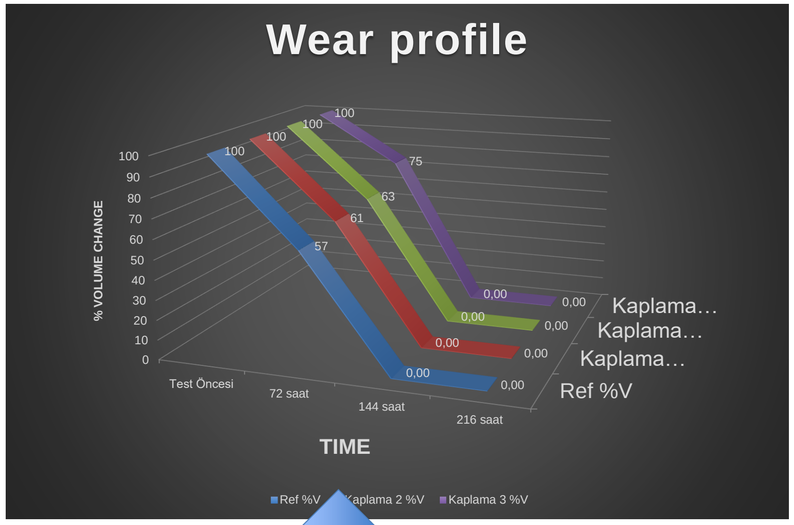


Dynamic Corrosion Test for AZS Refractories

- Target temperature 1450°C
- Heating rate 100°C / hour
- Test duration 72 hours (at target temperature)
- Sample rotation frequency 6rpm
- Sample cooling rate at the end of the test: 100°C / hour



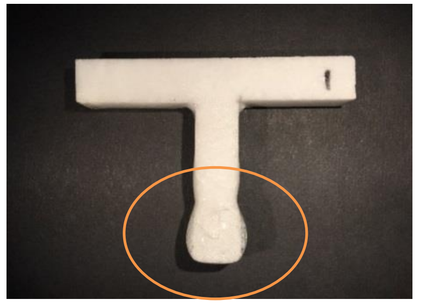


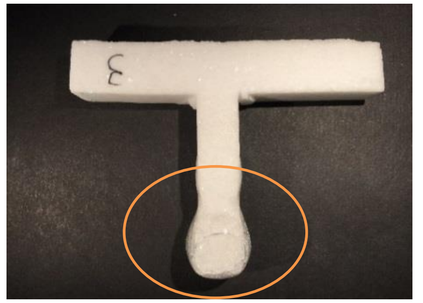


Stone/Finger Test for Alumina and AZS Refractories

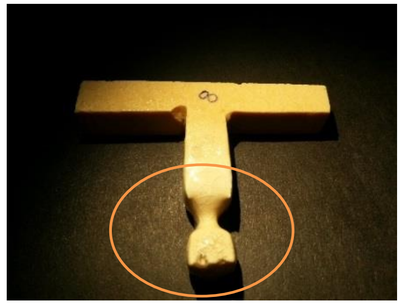
- Same batch as in the corrosion test,
- Pour them into platinium pots,
- Put the T-shaped refractory samples into the pots and set the furnace 1450^{o}C for 48 hours.

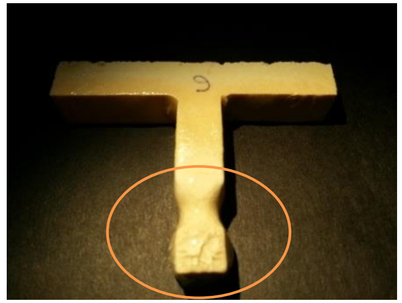
AZS Refractories





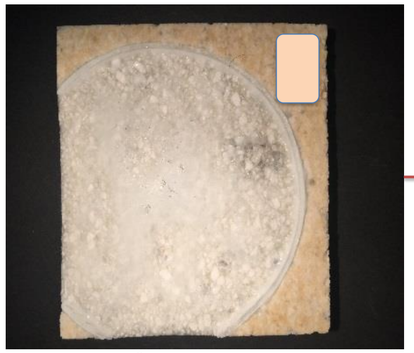
Alumina Refractories



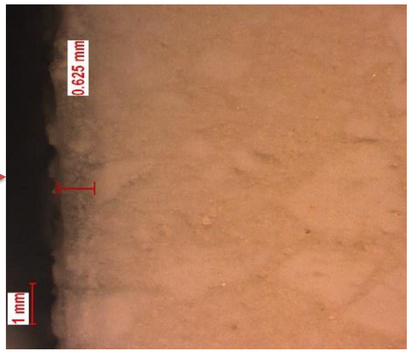


Alkaline Penetration Test for Silica Refractories

- Batch is %100 Na_2CO_3
- Pour it into a pot,
- Mount the refractory sample onto the pot,
- Refractory sample dimensions are 1x8x8cm3
- Set the temperature 1450^0C for 5 hours

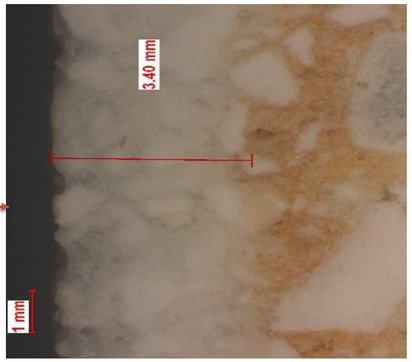


Surface Image A



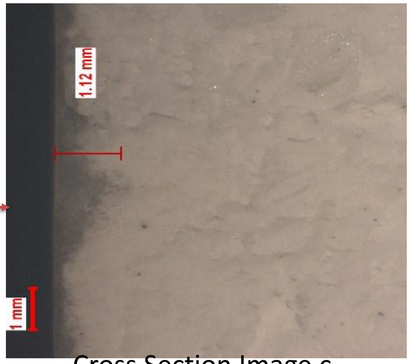
Cross Section Image A

Surface Image B



Cross Section Image B

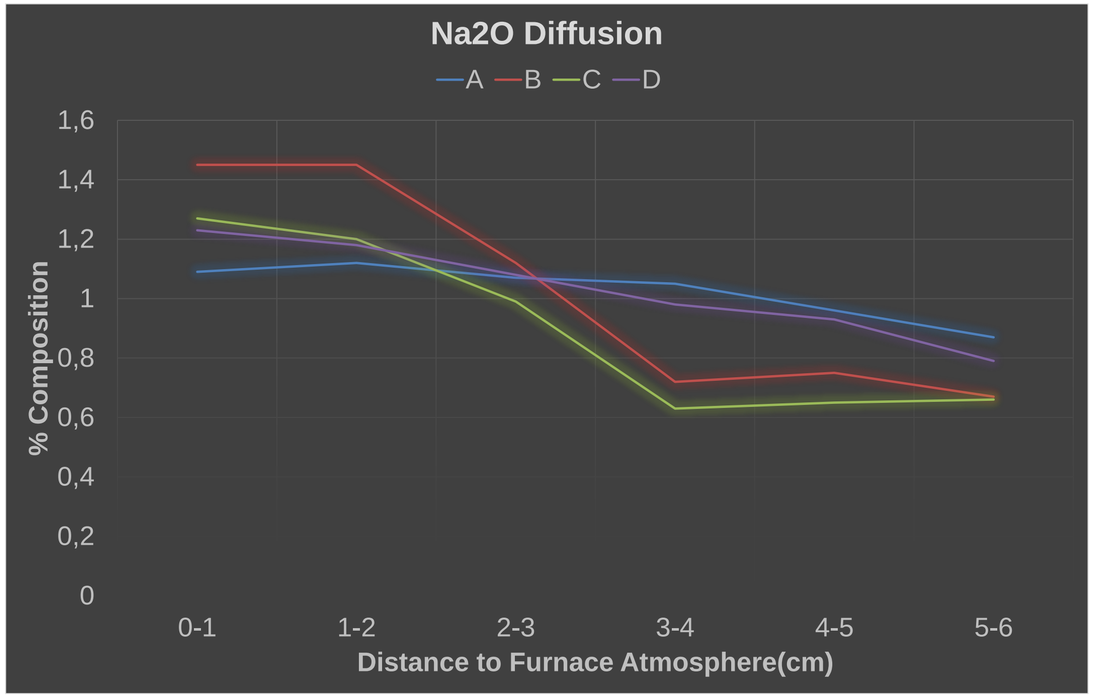
Surface Image C

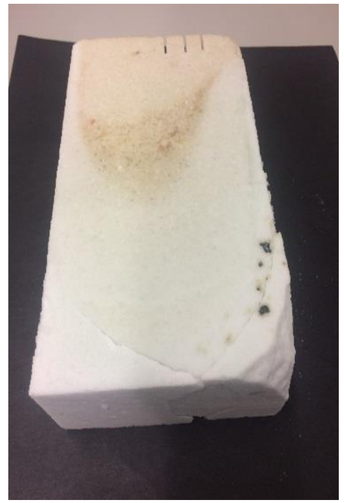


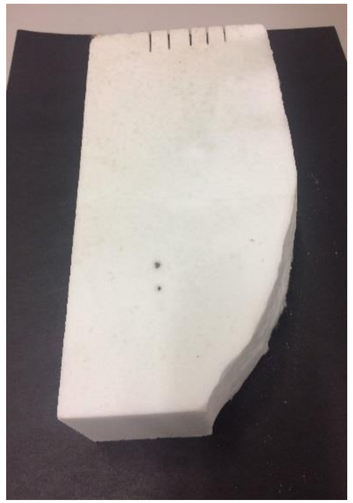
Cross Section Image c

In-Situ tests for Silica Refractories

- Using silica bricks itself in factories for a couple months,
- providing them same conditions during trials,
- and finally measure the Na2O contents of refractories inward by XRF.







Sample A

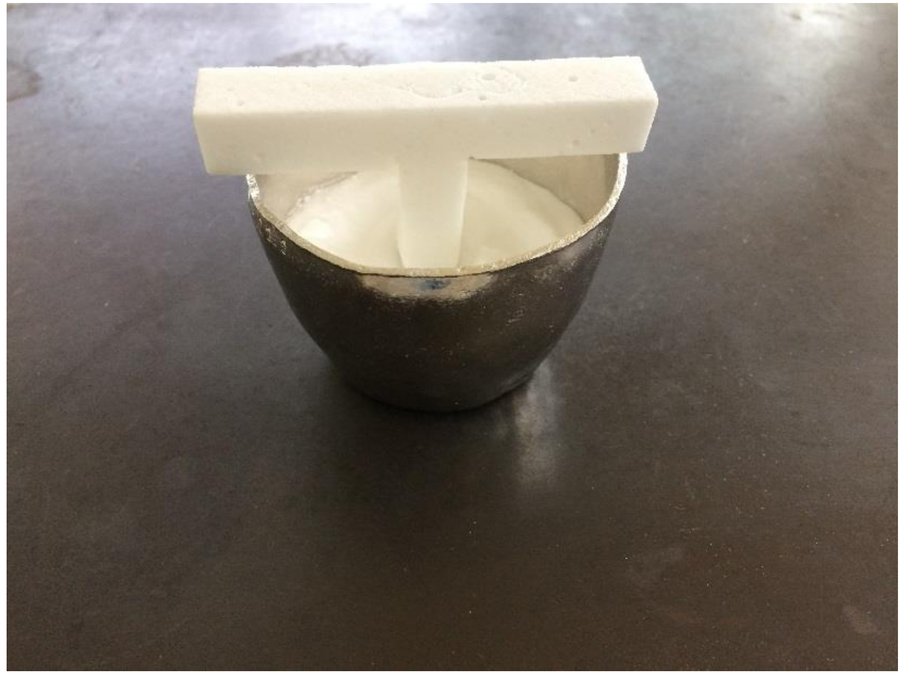
Sample B

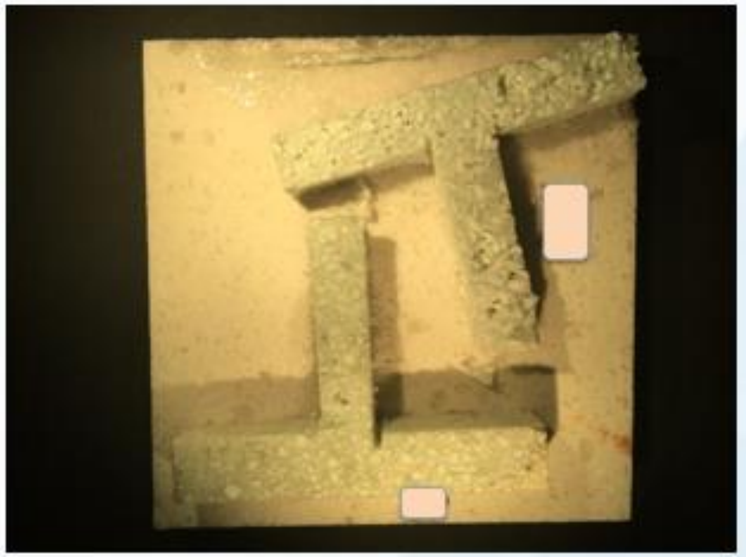
Sample C

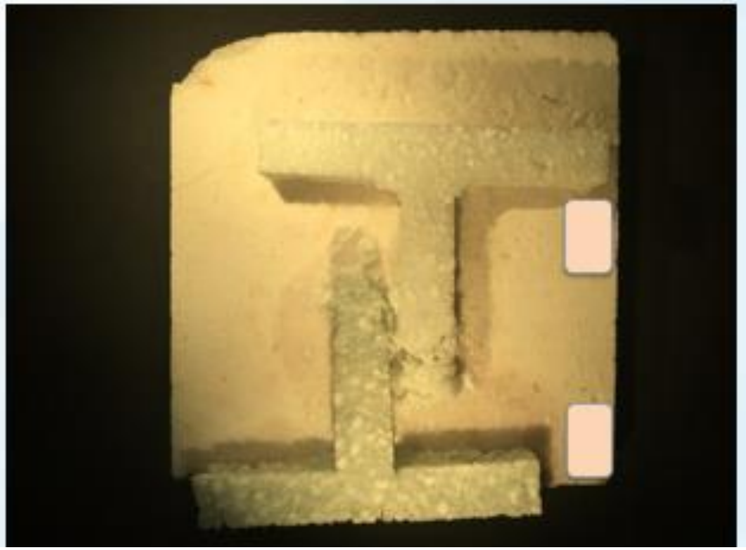
Sample D

Sulphate Attack Test for Silica Refractories

- Batch is %100 Na_2SO_4 in a pot,
- Melt it in the furnace which is set to 1100 ^{0}C,
- Then put the T samples into the platinium pot for 5 min.,
- Set the furnace again 1450 ^{0}C for 5 hours.



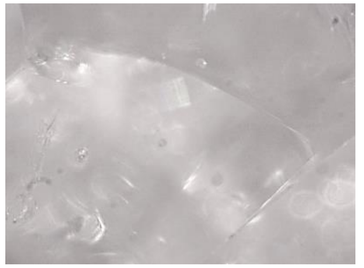


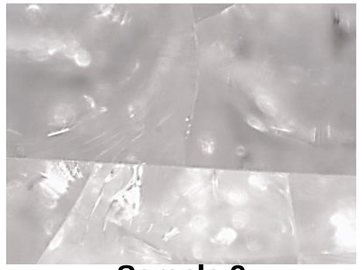


Bubble Test for glass contact Refractories

- Put 10mm thick glasses on refractory samples and set the first temperature at 600ºC for an hour,
- Then set the temperature 1200ºC for 1,5 hour and take them into the annealing furnace for controlled cooling.
- Check the glasses on refractories by microscope and compare the bubble intensities.

Sample	Degree (bubble intensity)	Condition
1	2	Good
2	1	Good
3	1	Good
4	2	Good
5	2	Good
6	5	Moderate
7	8	Bad
8	10	Bad


Sample 1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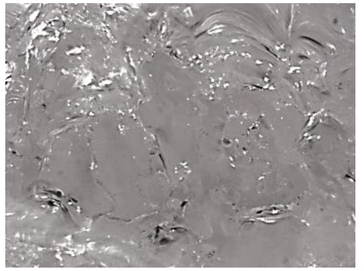
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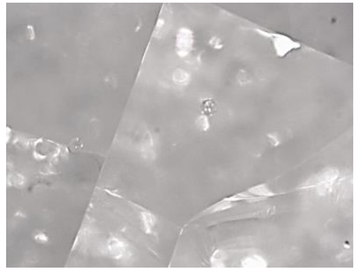
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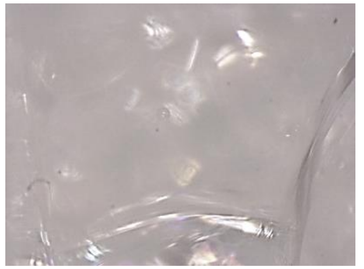
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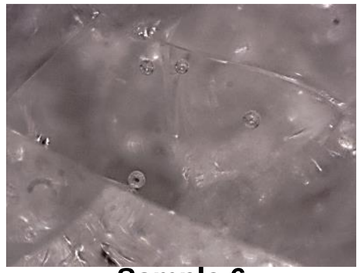
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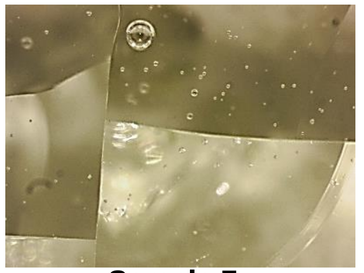
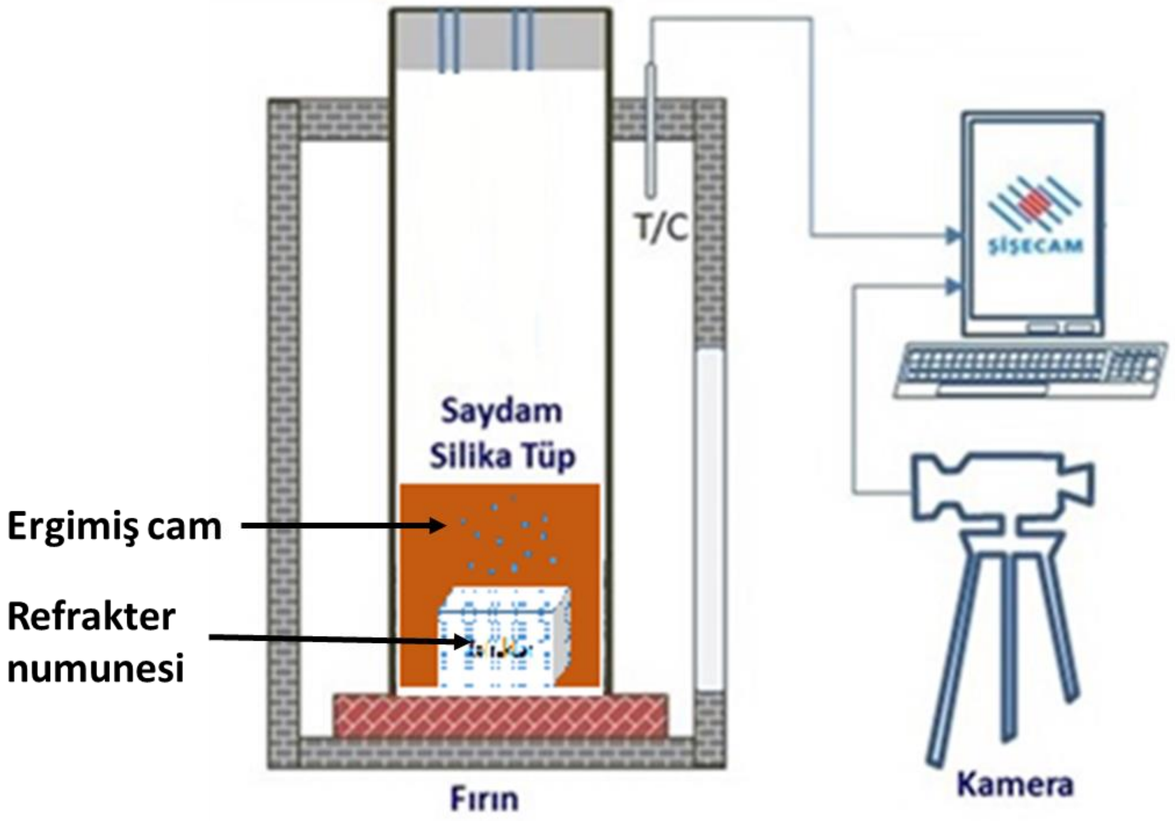
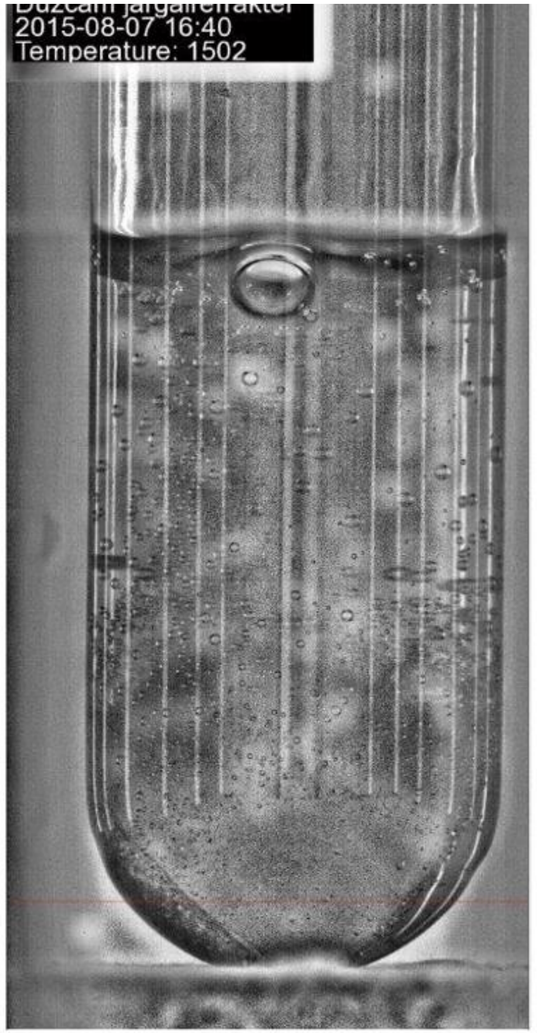
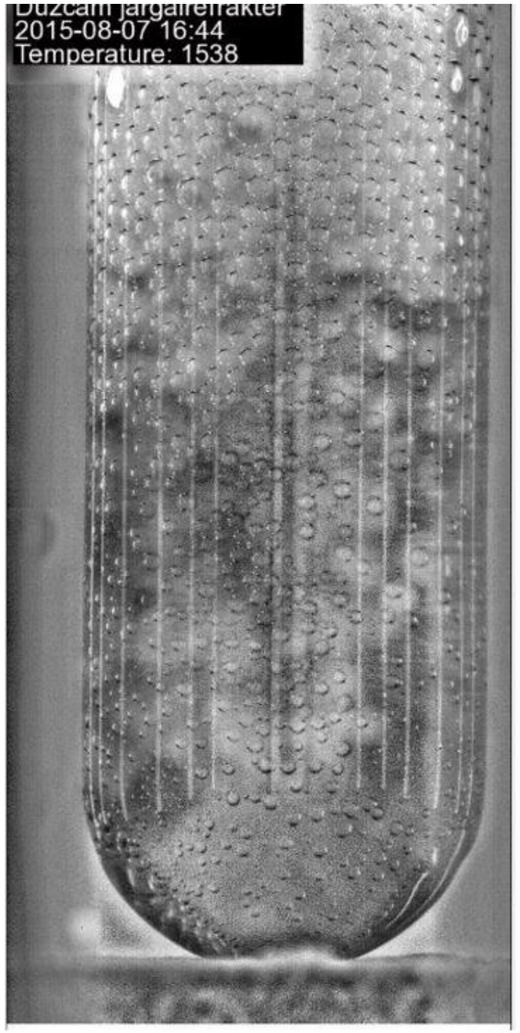

Sample 7


Sample 8

Determination of Bubble Potential of Glass Contact Refractory Materials







Results and Discussions

	Type/s	For	Remarks/Observations
Alkaline Penetration Test	• Silica	Estimate & compare of alkaline penetration resistance of silica refractories against frost defects	In-situ tests assist to see alkaline penetration
Sulphate Attack Test	• Silica	Estimate & compare of chemical resistance of silica refractories	Represents also batch dusting resistance
Static/dynamic Corrosion Test	• AZS • Alumina	Estimate & compare of wear resistance of glass contact refractories	Relationship between microstructure and corrosion resistance (AZS refractories)
Stone Test	• AZS • Alumina	Estimate & compare of stoning potentials of glass contact refractories	Quite similar to corrosion test, stone existance to be checked
Bubble Test	• AZS • Alumina	Estimate & compare of bubble potentials of glass contact refractories	Bubble tendency due to refratories
Exudation Test	• AZS	Estimate & compare of the glassy phase exudation tendency of superstructure refractories	Especially important for AZS refractories used in melting furnace