

Institute Of Refractories Engineers

Introduction To Refractories

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J Theron

What is a refractory?



The term refractory appeared in 1539 in Robert Estienne's dictionnarium latino-gallicum. Etymologically, it comes from the Latin word "Refractarius" meaning quarrelsome and disobedient.

A material can be described as refractory if it can stand up to the action of corrosive solids, liquids or gases at high temperatures (>?°C)

What does a refractory do?

Put simply: 'Contain or work within high temperature environments'

To do this a refractory must be able to withstand :

- high temperatures
- variable temperatures
- chemical attack by gases
- chemical attack by liquids
- > physical stresses
- mechanical wear

(both separately and in combination)



The importance of Refractories



 Frank Scott Russel (1878-1943) : "We know full well, that there can be not a gun, not a tank, not a ship, not a shot, not a shell – nay, not even a needle for a bandage – without refractories,...."



Refractory Applications



Glass



Petrochemical



Aluminium



Cement/ lime





Iron & Steel



Waste incineration

Industry Segments – Refractory Utilization





Sources of Important Raw Materials for Refractory



Suppliers of Refractory Products and Raw Materials



S.No.	Major Manufacturers of Refractory	Major Suppliers of Raw Material for Refractory
1	RHI AG	Imeris
2	Vesuvius (Cookson Group)	Kyanite Mining
3	Korsaki	Unifrax
4	Harima	Almatis
5	Magnesite	Rio Tinto
6	Shinagawa	
7	Chosun	
8	ANH	
9	Saint-Gobain	
10	Minteq (Materials Technologies)	
11	Allied Mineral products	
12	Morgan Crucible	
13	Resco Products	DigitalShor

Six Oxides of Refractory



However, the melting temperature is generally decreased by impurities in the same way as salt decreases the melting point of ice.

Mixing two high purity oxides







Influence of Sodium as impurity



System Na₂O-Al₂O₃-SiO₂; composite.

E. F. Osborn and Arnulf Muan, revised and redrawn "Phase Equilibrium Diagrams of Oxide Systems," Plate 4, published by the American Ceramic Society and the Edward Orton, Jr., Ceramic Foundation, 1960.

Principal References

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 F. C. Kracek, J. Phys. Chem., 34, 1583-98 (1930).
 N. L. Bowen and J. W. Greig, J. Am. Ceram. Soc., 7, 238-54 (1924); corrections, ibid., 410.
 N. A. Toropov and F. Ya. Galakhov, Voprovy Petrogr. i Mineralog., Akad. Nauk S.S.S.R., 2, 245-55 (1953).
 Shigeo Aramaki and Rustum Roy, Nature, 184, 631-32 (1969).
 J. F. Schairer and N. L. Bowen, Am. J. Sci., 254, 129-95 (1956).
 Liberto De Pablo-Galan and Wilfred R. Foster, J. Am. Ceram. Soc., 42, 401-98 (1959).







What are refractories made from?



Source of raw material





Source of raw material – hand picking



Source of raw material – variation in quality





Crushed raw material





Purification of magnesite used for production of Magnesia bricks



Sintered Magnesia (Periclase)





Fused Magnesia (Periclase)





Firing of pressed bricks





Visual image of 50% Al₂O₃ used for alkali environments



Optical image of 50% Al₂O₃ used for alkali environments





SEM micrograph of 50% Al2O3 used for alkali environments





Large grains cracked by pressing process, black areas indicate open pores

SEM 30X

Cold Face Frame 2

SEM (100X) micrograph of 50% Al2O3





Large aluminasilica (51%-46%) grains with 3:2 mullite and cristobalite crystal structure

SEM (1000X) micrograph of 50% Al2O3



Silica rich matrix with evidence of phosphate bond and SiC grains

<u>60µm</u>

Cold Face 3

Refractory castable





SEM (50X) micrograph of 85% Al2O3 castable





Circular black areas indicate castable air bubbles

SEM (300X) micrograph of 50% Al2O3





Large uniform alumina-silica (78%-22%) grains – mullite (3Al2O3:2SiO2)

SEM (1000X) micrograph of 85% Al2O3



SEM micrographs of 60% Al₂O₃ castable from cold to hot face







Hot face1400°C

Sample 3.4 half way



SEM micrographs of 60% Al₂O₃ castable from cold to hot face





Sample 1 cold face

Sample 31

200µm

Sample 5 hot face 7





Final Comment

Raw materials are the first step to produce a quality refractory product and is very similar to wine making: *"you cannot make a good wine without a good grape"*



Enjoy the rest of your day.