INTRODUCTION TO CERAMICS, GLASS AND REFRACTORIES

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10) REFRACTORIES

Refractories are materials that can withstand high temperatures without softening or deformation in shape. Refractories are mainly used for the construction of lining in - furnaces, kilns, converters, etc. The main function of a refractory is to withstand and maintain high temperatures and to resist the abrasive and corrosive action of molten metals, slags and gases.

DESIRED CHARACTERISTICS OF REFRACTORY

(a) It should be infusible at the operating temperatures.

(b) It should be chemically inert towards the corrosive gases, metallic slags and liquids.

(c) It should resist the abrading action of flue gases, flames, etc.

(d) It should not crack and suffer loss in size, at the operating temperatures.

(e) It should expand and contract uniformly, with temperature rise and fall respectively.

(f) It should be able to withstand overlying load of structure, at operating temperatures.

(g) It should have high refractoriness (withstanding high temperature)

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Neutral Refractories
Inert to both acidic and basic slag
Graphite, SiC and ZrO2

Classification of Refractories by their Chemical Nature

Acid Refractories
Reacts with basic Slag
Silica and Alumina

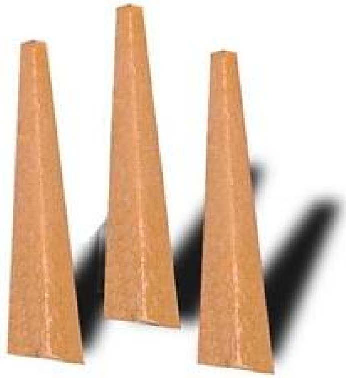
Basic Refractories
Reacts with acidic Slag
Calsite, Dolamite and Magnesite

Classification of Refractories by their Physical Properties

1) Refractoriness: is the ability of a material to withstand very high temperature without softening or deformation under particular service condition. It is measured in terms of Pyrometric cone equivalence.

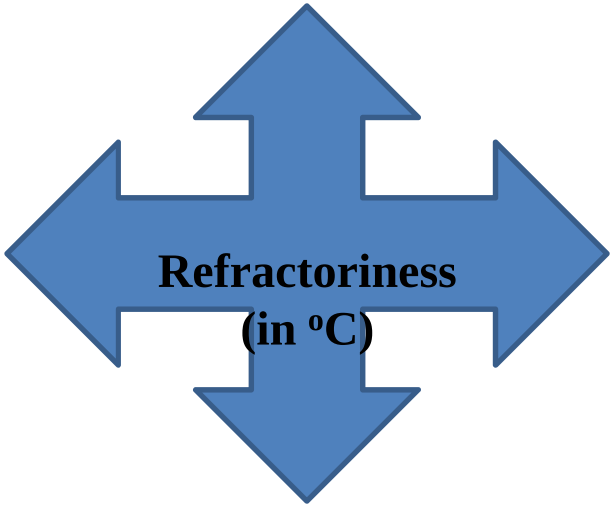
Pyrometric Cone Equivalent (PCE) Measurement

Temperature at which the refractory brick or the cone bend (ie) the temperature at which apex touches the base is called refractoriness (units PCE)



Low
١٥٢٠ - ١٦٣٠ (PCE 19 –28)
Calcite

Super
≥١٧٣٠
PCE 33-38
Magnesite



Intermediate
١٦٣١-١٦٧٠
(PCE 28-30)
Fireclay

High
١٦٧١- ١٧٣٠ (PCE 30-33)
Chromite

Why PCE Test

1. To determine the softening temperature of a test refractory material.
2. To classify the refractories.
3. To determine the purity of refractories.
4. To check whether the refractory can be used at the particular servicing temperature.

2) Porosity

The **porosity of a material is a measurement of how much of its volume is open space (also called pore space). Porosity is usually expressed as a percentage of the material's total volume.**

%Porosity (P) = 100 x (W - D)/ (W – S)

W = Weight of saturated specimen (with water) in air.
D = Weight of dry specimen.
S = Weight of saturated specimen (with water) suspended in water.

Disadvantages of high porosity refractory

(i) It reduces the strength.
(ii) It reduces resistance to abrasion.
(iii) It reduces the resistance to corrosion.

Advantages of high porosity refractory

(i) Highly porous refractory possess lower thermal conductivity hence it can be used for lining in furnaces, ovens, etc.
(ii) Highly porous refractory reduces thermal spalling.

3) Thermal Spalling

Thermal spalling is the property of breaking, cracking or peeling off a refractory material under high temperature. This can be caused by rapid change in temperature causes uneven expansion and contraction or by slag penetration.

4) Dimensional stability

It is the resistance of a refractory to any volume changes, when exposed to high temperature over a prolonged time.

(i) Reversible dimensional changes: This may result due to the uniform expansion and contraction of a refractory material.

ii) Irreversible dimensional changes: This may result either in the contraction or expansion of a refractory.

Magnesite (Amorphous) SG = 3.05 $\xrightarrow[\text{Shrinks}]{\text{Heating}}$ Periclase (Crystalline) SG = 3.54

Silica bricks expand on heating due to the transformation of one form to another forms.

Quartz Crystalline) $\xrightarrow[\text{Volume increase}]{\text{Heating } 870^{o}C}$ Tridymite $\xrightarrow{1475^{o}C}$ Cristobalite

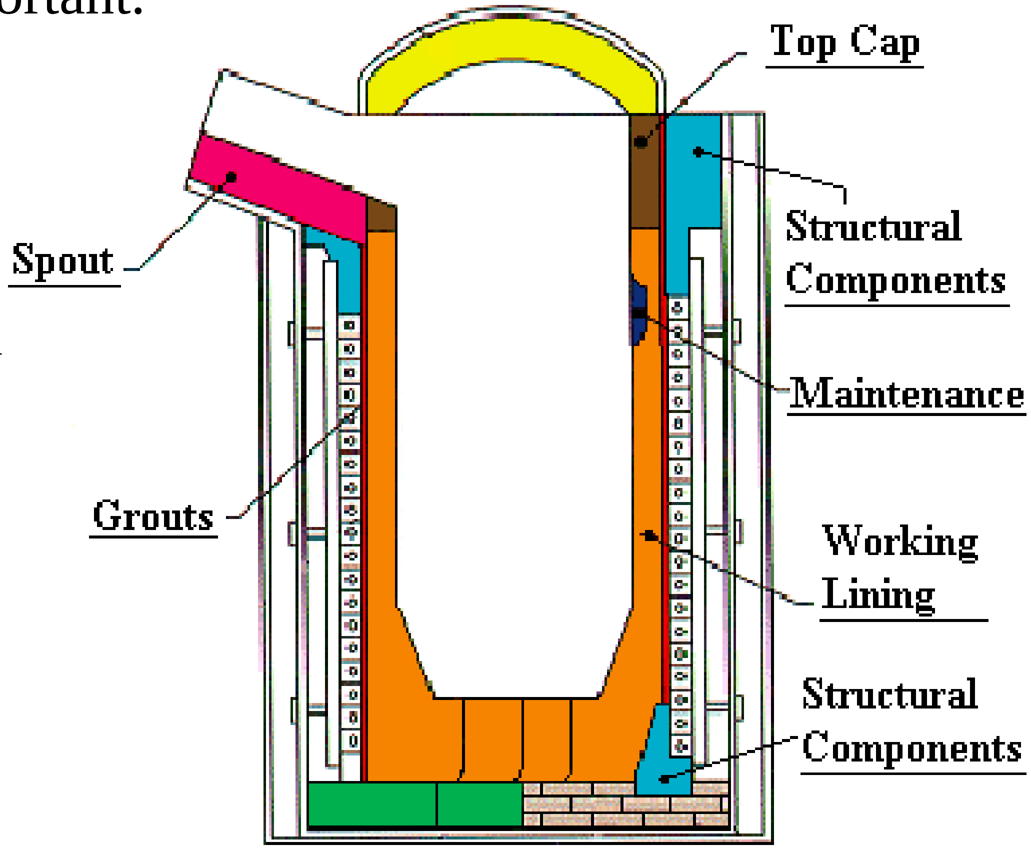
5) Strength

It is the resistance of the refractory to compressive loads, tension and shear stresses.

In taller furnaces, the refractory has to support a heavy load; hence strength under the combined effect of temperature and load, i.e. refractoriness under load is important.

Physical form

Refractory materials are either pressed bricks or hand formed using graded powder and water such as: 1) Ramming: Wet ramming masses are used immediately on opening. 2) Castables refractory materials contain binder such as aluminate cement 3)Mortars are finely ground refractory materials used to fill the gap created by a deformed shell



General Method of Manufacture of Refractory Bricks

Graded Powder Preparation

Crushing

Crush large lumps of raw material to ~25 mm size.

Method: Hammer mills / Machine crushing

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Grinding

Reduce powder from 25mm size raw material to 200 mesh size

Method: Jaw crushers / Ball mills

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Screening

Remove impurities from raw material

Method: Settling / Magnetic separation / Chemical methods

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Mixing

Mix various raw materials for proper distribution in order to facilitate moulding

Forming and Final Product

Moulding
Aim: To provide the required shape and structure
Method: Hand moulding / Mechanical moulding followed by dearing

Drying
Aim: To remove moisture and volatile matter
Method: Tunnel driers heated by steam

Machining Or Smoothing
Machining to final dimensions or smoothing seems and other roughness
Method: Lathe machine or sanding papers

Firing
Strengthen and stabilize the refractory
Method: Heating in Tunnels / Shaft / Rotary kiln
Firing Temperature: 1480oC for Super duty bricks, 1700oC for Acidic bricks and 1870oC for Basic bricks