Refractories and their Uses

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What are Refractories?
Refractories are ceramic materials that can withstand high temperature as well abrasive and corrosive action of molten metals, slags and gases, without suffering a deformation in shape. The main objective of refractory is to **confine heat**.
ASTM C71 defines refractories as "...non-metallic materials having those chemical and physical properties that make them applicable for structures, or as components of systems, that are exposed to environments above 1,000 °F (811 K; 538 °C)"

E.g.-Alumina(Al_2O_3), Zirconia(ZrO_2)

CLASSIFICATION OF REFRACTORIES

Based on the chemical properties of their constituent substances, refractories are classified into three categories:

1. Neutral refractories: Made from weakly basic/acidic materials like carbon zirconia (ZrO_2) and chromium ($FeO.CrO_2$).
   Example: zirconia, SiC(carborundum) refractories.
2. Acid refractories: They consists if acidic materials like alumina (Al_2O_3) and silica (SiO_2). They are resistant to acid slag.
   Example: alumina, silica and fire clay refractories
3. Basic refractories: Consist of basic materials like Cao, MgO etc and are especially resistant to basic slag.
   Example: Magnesite, dolomite refractories

CHARACTERISTICS OF REFRACTORIES

A good refractory will possess the following characteristics:

- They should be infusible at the operating temperature
- They should be chemically inert
- Should have excellent heat, corrosion and abrasion resistance

- Able to withstand the overlying load of structures at the operating temperature i.e the refractories must possess mechanical strength
- They should not crack or lose size at the operating temperature
- expand and contract uniformly, with rising and fall of temperature respectively

PROPERTIES

• Refractoriness
• Refractoriness under load (or Strength)
•Dimensional Stability
•Thermal contraction
• Heat Capacity
•Texture
•Thermal Spalling
• Chemical Inertness
• Resistance to abrasion or
corrosion and erosion
• Thermal Expansion
• Thermal Conductivity
• Porosity
• Electrical conductivity
•Permeability

Refractoriness- Ability to withstand very high temperatures without softening or deformation under given service conditions.
Refractoriness under load (or Strength) - Refractories used in metallurgical operations should bear varying loads. It is, therefore, essential that refractory materials must possess high mechanical strength, even at operating temperature, to bear the maximum possible load, without breaking.
Dimensional Stability -Dimensional Stability is the resistance of a material to any change in volume when it is exposed to high temperatures, over a prolonged time.
Thermal contraction and expansion: Solid materials, on heating, expands and on cooling, they contract. So in the designing of the practical furnaces, a refractory material should have the least possible thermal expansion.
Heat Capacity: The dense and heavy fore clay bricks have a higher heat capacity and as such are best suited for regenerators, checker-works as in stoves for blast furnaces, coke ovens etc.

Texture: Course or light-textured bricks, because of their large porosity, are light in weight and hence, they are more resistant to sudden changes in temperature. However, their crushing strength is low. Such bricks are more susceptible to the action of abrasion and corrosion. On the other hand, fine or dense-textured bricks possess low porosity and hence are heavier than coarse and light-textured bricks. These are not so resistant to sudden changes in temperature. However, such bricks are less susceptible to action and corrosion.

Thermal Spalling: Rapid temperature changes, cause uneven expansion and contraction of refractory material, thereby leading to the development of internal stresses and strains. This is the turn is responsible for cracking, breaking or fracturing of refractory brick or block under high temperature, collectively known as thermal spalling.

Chemical Inertness: A refractory material which is used as a liner for furnace walls should be selected such that it is chemically inert in use and does not form fusible products with slags, fuel ashes, furnace gases and other chemicals charged into a furnace.

Resistance to abrasion or corrosion and erosion: For refractory to the last longer, it should have excellent corrosion and erosion resistance. This property is very important for the selection of refractory material for by-product coke-oven wall and lining of discharge ends of rotary cement kilns etc.

Thermal Conductivity: In industrial operations, refractory materials of both high thermal conductivity and low thermal conductivity are required, depending upon the type of the furnace. In most cases, furnaces are lined with refractories of low heat conductivities to reduce the heat loss to the outside by radiation; otherwise maintenance of high temperature inside the furnace will become difficult.

Porosity: All refractories contain pores, either due to manufacturing methods or deliberately made (by incorporating saw-dust or cork during manufacture). Pores can alter the properties of a refractory. *Porosity is the ratio of its pore's volume to the bulk volume*. Porosity is an important property because it affects many other characteristics such as chemical stability, strength,abrasion-resistance and thermal conductivity. In a porous refractory; molten charge, slags, gases etc. are likely to enter more easily to a greater depth. They may react and reduce the life of the refractory material.

Electrical conductivity: A good refractory must have shown low electrical conductivity.

Permeability: It is a measure of the rate of diffusion of molten solids, liquids and gases through the connected pores of refractory. A good refractory material should show low permeability.

USES OF REFRACTORIES

- Refractory materials are used in linings for furnaces, kilns, incinerators and reactors.
- They are also used to make crucibles and moulds for casting glass and metals and for surfacing flame deflector systems for rocket launch structures.
- Today, the iron- and steel industry uses approximately 70% of all refractories produced.
- Manufacturing of cement, glass, paper, metals

- SiC refractories: are mainly used in muffles. It is also an ideal choice for recuperaters.
- Fire clay refractories: They are mostly consumed by steel industries. They are widely used in foundries as well.
- Magnesium Refractories: Mainly used in the steel industry for the lining of basic converters and open-hearth furnaces.
- Dolomite refractory: generally used as a repair material. It is also used as a cheap substitute of magnesium bricks.