REFRACTORIES AND IT'S USES

BY-

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INTRODUCTION

- Refractory materials are non-metals of construction, capable of withstanding high temperatures without appreciable deformation under service conditions.

- 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(Al2O3), Zirconia(ZrO2)

- The property to withstand high temperatures without appreciable deformation under various service condition is termed as “Refractoriness”.
Dry press process
This process is ideally suitable to the formation of simple solid shapes. It is particularly suited to clays of very low plasticity. Clay is mixed with a minimal amount of water, then pressed into steel molds under pressures by hydraulic or compressed air rams. Because the dry press process is so simple and involves low capital equipment costs it is the most widely used high-volume forming process for ceramics.

The manufacturing process has six general steps: 1) mining and storage of raw materials, 2) preparing raw materials, 3) forming the brick, 4) drying, 5) firing and cooling and 6) de-hacking and storing finished products.
Fused cast
Fused cast involves melting refractory material in a electric furnace followed by casting and annealing are treated with oxygen while in the molten state to place the constituents in the most highly oxidized state. This method minimizes the exudation of the glassy matrix of the refractory during service. The raw materials for the refractories may be oxidized before melting by heat treating to reduce the oxygen necessary for oxidizing the molten refractory. High density, small or large shapes are obtained. When appropriate, a finish is made by grinding with diamond tools.

Hand molded
The mold is made by hand. Hand molded refractories do not have the smooth surface of machine made brick. This method is especially well adapted to small
Formed

Firebrick is a common example of formed refractory. Formed refractories are manufactured by either fired or chemically bonded method.

Fired refractories is formed by heating the refractory material to high temperatures in a kiln to form a ceramic bond. This process gives the raw materials their refractory properties.

Chemically bonded refractory brick, also referred to as unfired brick, is formed with the aid of selected additives that set up at room temperature and provide structural integrity, eliminating the need for high-temperature sintering. It offers significant energy savings by eliminating the need for high-temperature processing. In addition, the many methods for modifying the chemical bond can develop new compositions to withstand a variety of severe environments encountered in many industrial processes.
CHARACTERISTICS OF REFRACTORIES

A good refractory will possess the following characteristics:

- They should be infusible at the operating temperature
- They should be chemically inert
- Resists the abrasive action of flue gases, flames, etc
- 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 rise and fall of temperature respectively
PROPERTIES

• Refractoriness
• Strength
• Chemical Inertness
• Resistance to abrasion or corrosion
• Thermal Expansion
• Thermal Conductivity
• Porosity
• Electrical conductivity
• Texture
REFRACTORINES

- Ability to withstand very high temperatures without softening or undergoing any change in shape
- Refractoriness varies from one material to another. So refractoriness has to be measured.
  
  They don’t have sharp melting points because they are prepared from inorganic compounds and usually they are a mixture of compounds. On increasing the temperature they soften. So at particular temperature when they soften, the temperature is taken as SOFTENING TEMPERATURE. The softening temperature is expressed in terms of a number known as PCE(Pyrometric cone equivalent)
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.
- Some refractories like fireclay, high Alumina bricks softens gradually over the range of temperature, but under appreciable load, they collapse, far below their true fusion point, as determined by pyrometric cones.
- On the other hand, other refractories such as Silica bricks softens over a relatively narrow range of temperature and exerts good load bearing characteristics close to their fusion points.
PCE values are determined by taking the refractory material and converting it into a pyramidal cone, pyrometric cone (materials whose PCE values are known or taken).

All these are kept in an electric furnace and furnace is heated steadily at a heating rate of 10 °C per minute. With rise in temperature, the temperature of the cones will also rise. The test cone will start softening. When it starts softening the apex will start bending. It goes on bending and finally touches the base. The temperature at which the apex of the cone touches the base is taken as softening temperature. Softening temperature is not expressed in °C but as PCE values.
A refractory should be selected such that it is chemically inert in use and does not form fusible products with slags, fuel ashes, furnace gases, etc. Usually, the environment in most furnaces is either acidic or basic.
THERMAL SPALLING

- Property of breaking, cracking, peeling off the refractory at high temperature
- A good refractory must possess very good resistance to thermal spalling.
- Thermal spalling is due to 2 reasons: a) Rapid change in temperature
  b) Slag penetration
RESISTANT TO CORROSION

A good refractory must show good resistance to abrasion or erosion.
Solid materials, on heating, expands and on cooling they contract. So in the designing of the practical furnaces, a refractory material should have least possible thermal expansion as the expansion affects all the dimensions (e.g. length, area, volume) of the body.
DIMENSIONAL STABILITY

- Resistance of a refractory to any volume change when exposed to very high temperature over a long time.
- The heat can cause 2 types of changes- a) Reversible
  b) Irreversible
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.

• A good heat conductivity of the refractory material is desirable for effective heat transmission in the construction of the furnace.
**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 show low electrical conductivity.
- Except graphite, all other refractories are poor conductors of electricity.
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.
1. Fire resistant refractory brick

2. Ceramic Brick Refractories
USES

- 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.
Special Refractories

These are very expensive refractory materials used for making crucibles and furnaces for special / experimental purposes where the cost of refractory is no consideration.

They are not very common due to their manufacturing limitation.

Special refractory include pure oxides (eg. Magnesia, Silica, Alumina, Thoria etc), borides, nitrides, silicides, carbides etc.

Other special refractories are Sialons (Silicon Alumina Oxy Nitride), Zircons, bricks of mullite, magnesia and mixtures of chromite, bauxite and magnesite.
THANK YOU