Lecture 15: Application of Refractory Materials

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Key words: Refractory, furnaces, Insulation

What are the available Refractory materials

The available refractory materials are classified

(a) Oxidic type and (b) special type

**Oxidic refractory**

<table>
<thead>
<tr>
<th>Acid</th>
<th>Basic</th>
<th>Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td>(SiO₂ is the main constituent)</td>
<td>Magnesite</td>
<td>Chromite</td>
</tr>
<tr>
<td><strong>Example</strong></td>
<td><strong>Under acidic conditions</strong></td>
<td><strong>Under basic conditions</strong></td>
</tr>
<tr>
<td>fireclay</td>
<td>MgO – C</td>
<td>Carbon</td>
</tr>
<tr>
<td>Quartz</td>
<td>Alumina</td>
<td>Mullite</td>
</tr>
<tr>
<td>Silica</td>
<td>Dolomite</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alumina – C</td>
<td></td>
</tr>
</tbody>
</table>

(b) Special type

Silicon carbide, cermets and SIALON are some examples of special refractory. They are used for special applications.
Description of some refractory

Fireclays

Common fire clays contain 25 to 45% $\text{Al}_2\text{O}_3$ and 50-80% $\text{SiO}_2$. Clays with higher $\text{Al}_2\text{O}_3$ are higher alumina refractories.

Properties

- Porosity varies from 8 to 24% depending on the firing temperature.
- At high temperatures fire clay refractory combine with alkalis such as soda and potash.
- Cold crushing strength is 950 kg/cm² at 20°C and decreases drastically at 800°C to 555°C.

<table>
<thead>
<tr>
<th>Al₂O₃ (%)</th>
<th>Refractoriness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium duty</td>
<td>30 - 32</td>
</tr>
<tr>
<td>High duty</td>
<td>38 - 40</td>
</tr>
<tr>
<td>Super duty</td>
<td>42 – 45</td>
</tr>
</tbody>
</table>

**Uses:** Furnaces, regenerators, ovens, and kilns.

High alumina refractories:

$\text{Al}_2\text{O}_3$ varies from 45 to 95%. Commonly used refractory are sillimanite ($\text{Al}_2\text{O}_3$ 61%) and mullite (70 – 85% $\text{Al}_2\text{O}_3$). Some of the properties are

- High refractoriness
- Better resistance to slag and spalling
- Higher load bearing capacity.
- Fusion point >1850°C.

**Uses:** B F stoves, cement and lime rotary kilns, electric are furnace roofs, ladle, glass making furnaces, etc.
**Chromite – Magnesite:** Amount of chrome ore is > magnesite. Some properties are

- Used up to 1700°C.
- Resistant to thermal shocks
- Basic in nature

Uses in: Inner lining of basic oxygen steelmaking vessel, Side walls of soaking pits etc

**Magnesite:** These refractory are basic in nature. Some properties are

- High refactororiness and thermal conductivity
- Great resistance to basic slag

**Silicon carbide**

SiC content exceeds 85% in these type of refractories. Some of the important properties are

Properties:

- High thermal conductivity and high refactororiness
- Resistance to thermal spalling and temperature load bearing capacity is high
- Inert to acid slags and
- Light weight

**SIALON:**

This class of refractory is prepared by using alumina and silicon nitride. Powdered mixture of alumina and silicon nitride is hot pressed at 18 – 30 M Pa and 1700 – 1760°C in graphite moulds in order to produce a low porosity dense product. SIALON refractory shows

i. good resistance to oxidation, and action of molten metals like Al, Zn, Cd, Fe and steel and
ii. resistance to H₂SO₄, HCl, borax and alkalis.

**Manufacture of a refractory**

Note that refractory used in high temperature furnaces does not occur as natural reserves. But refractory is produced by using naturally occurring materials like quartz, magnesite, dolomite, chromite, bauxite etc.

A general flow sheet is given in the following to illustrate the various steps and their functions.
Emerging trends

Refractory has undergone many changes to meet the diversified requirements of the industry particularly steel industry. The main objective is to increase the lining life at reduced cost by developing

a) High quality refractory for critical applications in steel making at e.g. slag line, impact area of molten steel stream, bottom tuyere refractory in hybrid blowing, immersion nozzles in continuous costing etc. In this connection mention may be made of some refractory like MgO-C, Al₂O₃ – Si C – C, MgO – Ca O – C, Al,Mg and Al-Si alloy stabilized MgO – C brick, zircon based refractory, and Al₂O₃ – C

b) Repairing methods like slag splashing, slag coating, hot patching, gunning (flame gunning involves melting and spraying on hot surface).

c) Monolithic refractory

Monolithic refractory

Monolithic linings are a relatively recent development and consist of unshaped refractory products. These are materials which are installed in some form of suspension that ultimately hardens to form a solid mass. There are two basic types of monolithic lining, namely castable refractory and plastic refractory

Castable refractory consists of mixtures of coarse and fine refractory grains together with a bonding agent which is normally based on high alumina cement. Installation of the refractory is important. Due
to relatively poor strength, durability of monolithic lining depends on the design and installation of the anchors.

Monolithic linings are installed by casting the refractory in a mould or by spraying the furnace shell. Largest problem with use of monolithic refractories are:

- Long drying time
- Steam explosion.

Furnace refractory maintenance: The following methods are commonly practiced.

Slag splashing

Slag splashing is done in steelmaking vessels. After steel tapping, some amount of slag is retained. Composition of slag with respect to FeO and MgO is adjusted. FeO makes the slag adhesive on the lining and MgO makes the lining high temperature resistant. Nitrogen is blown from top to splash the slag. The splashed slag gets coated on the lining. To reduce excessive slag build up in the bottom, excess slag is then poured before charging.

In case of hybrid blowing practice formation of skull may result in a failure of the bottom stirring elements.

Slag coating and slag washing

The small amount of liquid slag is retained in the vessel after tapping. Slag is enriched with dolomite or raw dolomite to cool the slag and to increase its adhesive properties. Vessel is rocked several times to coat the bottom and bottom joint with a slag.

Hot patching

Self flowing refractory mixtures enable precise maintenance of the scrap impact zone, tapping pad and bottom joint.

Gunning

By gunning, i.e. maintenance of pre- worn areas with special gunning mixtures, vessel lining life can be extended.

Flame gunning involves simultaneous melting of a refractory powder and gunning at the hot surface. Since the gunned repair material is dense and fused directly on the hot surface excellent results on life of lining is obtained in LD converter.

Future issues of Refractory technology

1. Durability of refractory for pairing nozzles and side dams determines the success of strip casting.
2. Technology of mass melting of scrap in converter by using post combustion requires super- high temperature refractories.

3. Super fine powder processing technology to produce refractory.

4. Use of monolithic refractory in steel making and refining furnaces require to automate brick laying and intelligent repair.

5. Nano tech refractory is thermal shock and corrosion resistant The nano-particles act in two ways
   → They consist of mono spheres and improve properties like elasticity and strength
   → Control of molecular structure as the particles have many small pores of several hundred nano meters.

Reference: P.Mullinger and B. Jenkins: Industrial and process furnaces

O.P. Gupta: elements of fuels. furnaces and refractories.

Assignments:

1) What do you understand by the spalling tendency of a refractory brick? Give reasons.

2) What is meant by refractoriness under load? What is its importance?

3) Explain the term inversions in relation to the behavior of silica brick on heating and cooling.

4) Silica bricks are manufactured from a naturally occurring quartzite, which contains 98% SiO₂. Is it possible to use these bricks without any thermal treatment?

5) High alumina bricks are better than fireclay. Why?

6) High magnesite refractory show good resistance to attack by iron oxide. Why?

7) Why is it necessary to add anti-shrinkage material for the manufacture of fireclay briske from naturally occurring clay ores?

8) How are insulating bricks manufactured?