Lecture 5: MSE 402

Refractory material

Dr. Alka Gupta

Refractory material

Any material can be described as ‘refractory’, if it can with stand the action of abrasive or corrosive solids, liquids or gases at high temperatures

- A material having the ability to retain its physical shape and chemical identity when subjected to high temperatures.
- Refractories are inorganic, nonmetallic, porous and heterogeneous materials composed of thermally stable mineral aggregates, a binder phase and additives
- 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)".
- Refractories are heat resistant materials used in almost all processes involving high temperatures and/or corrosive environment.
- These are typically used to insulate and protect industrial furnaces and vessels due to their excellent resistance to heat, chemical attack and mechanical damage.
- Any failure of refractory could result in a great loss of production time, equipment, and sometimes the product itself.
- The various types of refractories also influence the safe operation, energy consumption and product quality; therefore, obtaining refractories best suited to each application is of supreme importance.

Four basic functions of Refractories

- They act as a **thermal barrier** between a hot medium (e.g., flue gases, liquid metal, molten slags, and molten salts) and the wall of the containing vessel;
- They insure a strong physical protection, preventing the **erosion of walls** by the circulating hot medium;
- They represent a **chemical protective barrier** against corrosion;
- They act as **thermal insulation**, insuring heat retention.

Requirements of Refractory

General requirements of a refractory materials are as follows:

- Its ability to withstand high temperatures and trap heat within a limited area like a furnace;
- Its ability to withstand action of molten metal , hot gasses and slag erosion etc;
- Its ability to withstand load at service conditions;
- Its ability to resist contamination of the material with which it comes into contact;
- Its ability to maintain sufficient dimensional stability at high temperatures and after/during repeated thermal cycling;
- Its ability to conserve heat.

Classification of Refractories

- On the basis of their chemical behavior:

a) Acid b) Basic c) Neutral

Classification Based on Method of Manufacture:

a) Dry Press Process

b) Fused Cast

c) Hand Molded

d) Formed (Normal, Fired or chemical bonded)

e) Unformed (Monolithic – Plastics, Ramming mass, Gunning, Cast able, Spraying

- Classification Based on Physical Form:

a) Shaped Refractories

b) UnsShaped Refractories

- Based on the oxide content:

a) Single oxide refractories

b) Mixed oxide refractories

c) Non-oxide refractories

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- According to their refractoriness:

S.NO	TYPE OF REFRACTORIES	PCE VALUE	REFRACTORINESS(^{0}C)	EXAMPLES
1	Low heat duty refractories	19-28	1520 – 1630	Silica bricks
2	Intermediate heat duty refractories	28-30	1630 – 1670	Fireclay bricks
3	High heat duty refractories	30-33	1670 – 1730	Chromite bricks
4	Super heat duty refractories	>33	>1730	Magnesite bricks

- Classified as dense or insulating types
- Other categories: Special refractories, Insulating Refractories, & Cermets

Melting points of some important refractories

REFRACTORY ELEMENT	MELTING TEMPERATURES (°F)
Graphite C Pure	6300 °F
Thoria, ThO_2 Pure Sintered	5430 °F
Magnesia, MgO, Pure Sintered	5070 °F
Zirconia, ZrO_2 , Pure Sintered	4890 °F
Lime, CaO	4660 °F
Beryllia, BeO, Pure Sintered	4620 °F
Silicon Carbide, SiC, Pure	4080 °F
Magnesia, 90-95%	3980 °F
Chromite, FeO-Cr_2O_3	3960 °F
Chromium Oxide	3880 °F
Alumina, Al_2O_3, Pure Sintered	3720 °F
Chromite, 38%, Cr_2O_3	3580 °F
Alumina Fused Bauxite	3400 °F
Silicon Carbide, 80-90%	3400 °F
Fireclay	3400 °F
Titania, TiO_2	3360 °F
Kaolin, Al_2O_3 -, SiO_2	3300 °F
Silica, SiO_2	3120 °F

Selection Criteria of refractories

Selecting refractory materials and designing insulation systems like furnaces etc. requires assessment of four factors:

- **Thermal performance:** thermal conductivity, temperature limit, melting or fusion temperature, heat capacity or storage, thermal expansion and spalling resistance
- **Physical properties:** density or porosity, abrasion, electrical resistivity, mechanical strength, wear and erosion resistance and other structural properties at high temperatures
- **Chemical characteristics:** uniformity of composition, reactions between operating environment and base materials and issues like volatilization of binding agents, corrosion, chemical attack or diffusion and reactions with the product.
- **Costs:** initial installation labor cost, maintenance, repair; and replacement costs.

References

1. Elements of Fuels, Furnaces and Refractories by O.P. Gupta, Khanna Publ., 1997
2. 2. Fuels and refractories by Book by J. D. Gilchrist

3. https://www.economicsdiscussion.net